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ABSTRACT

This book presents the results of a study done to determine whether the curricula available for secondary students are adequate for understanding growth implications of resource usage and for making predictions about the earth's future. The first section of the book is concerned with the evaluation committee's concensus on pedagogical criteria, curriculum goals, and underlying concepts. The second section relates the evaluation findings from the student perspective. (Secondary students were questioned with respect to world views, conceptual understanding, and problem identification, analysis, and evaluation.) The third section gives a review of the curriculum materials based on teacher evaluations and the last section states the numerous conclusions drawn from the study. The latter discusses eight areas of evaluation including student differences, pedagogy and teacher preparation, and systems skills. An appendix contains the student interview questions and the teacher curriculum review form, listings of the publishers surveyed and the educators and practitioners interviewed, and a bibliography of the curriculum materials reviewed. (MA)

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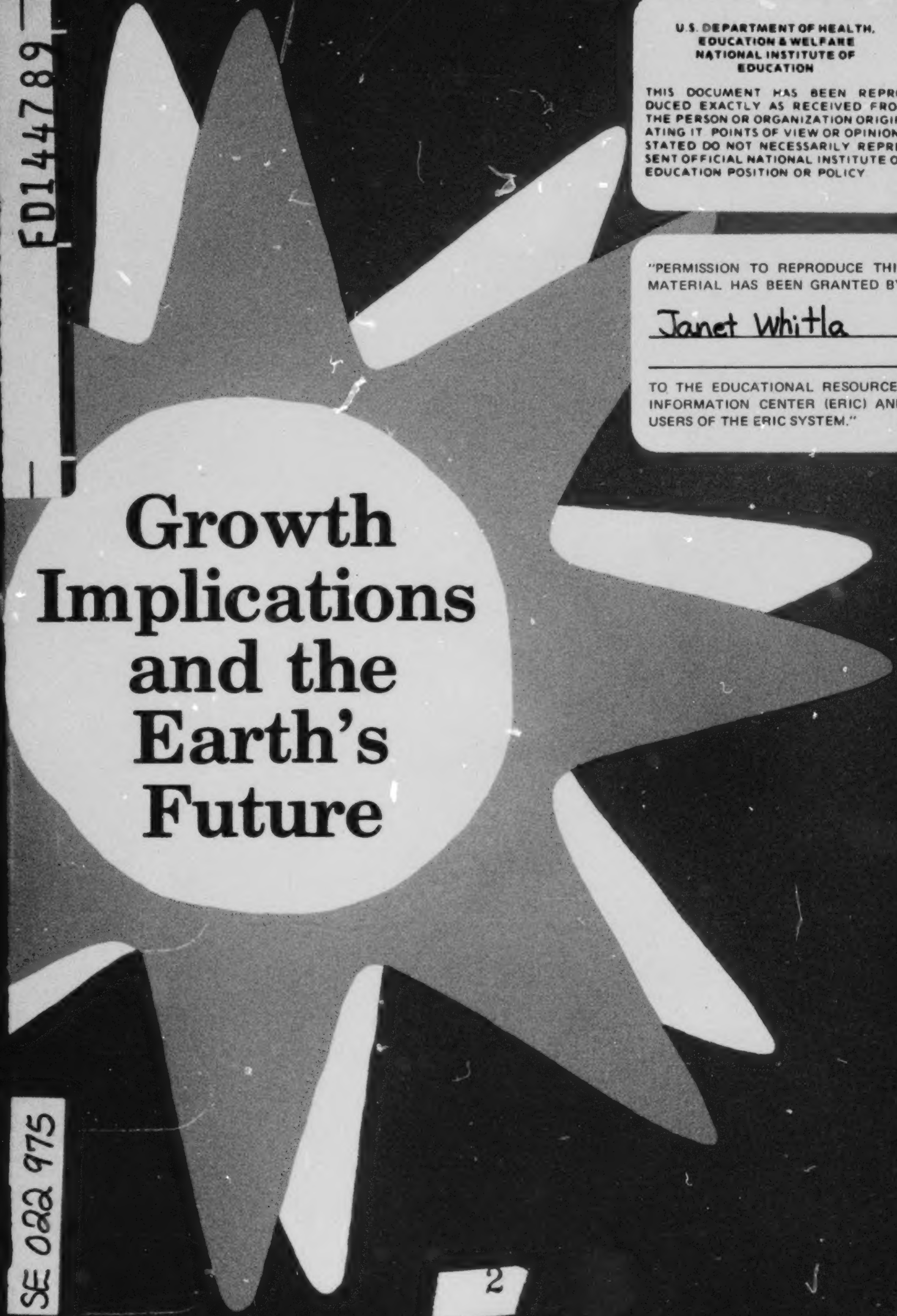

Growth Implications and the Earth's Future

[illegible] Materials and Student Views

SE 022 975

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A Position Statement

Readers will wish to know what point of view the authors of this report hold on the "limits-to-growth" controversy. Do we stand with growth opponents, growth proponents, or somewhere in between?

Individually, the authors hold a range of outlooks on the controversy. We all do agree, however, and see as the significant issue for this report, that indiscriminate growth may soon cause critical problems. We must begin now to equip the coming generation of adults with the understanding and conceptual tools they will need to recognize, analyze, and weigh possible solutions for growth-related issues. Concern and knowledge cannot be limited to experts but must become a responsibility shared by all citizens, because the actions and views of each person will affect the welfare of all.

One Outcome of the Study: A Growth Information Center

Readers may also be interested to know that one outcome of our work has been the establishment of an information center. The center, which houses a range of curriculum materials relating to growth and the earth's future, is open by appointment Monday–Friday. The purpose of the center is to make available to others the range of materials we have researched and to answer questions about environmental education programs. Materials are continuously being updated.

If you wish to visit the center, please contact Sandra A. Stevens, EDC School and Society Programs (617-969-7100), to set up an appointment.

Introduction

Purpose

This study was undertaken in response to the potential ecological crisis. We wanted to determine whether the curricula available for secondary school students are adequate for helping them to understand the range of economic growth implications, and to deal in long-term perspectives with the effective cultivation of the earth's resources and energy.

We realize that curriculum programs and materials comprise only one of the many educational resources available to youngsters. We believe they deserve particular attention, however, because the potential impact of even a small unit that is developed well is enormous: it can be replicated and made available to large numbers of students; it can be used in a broad range of situations, with diverse groups, at different times and places.

Approach

To assess the effectiveness of curriculum materials, it was not enough to examine the materials themselves. It was also important to have some perspective on the population that use environmental curricula: what they know and don't know, how they see the future, and what roles they see for themselves. Therefore, our study involved two tasks:

- an exploration of student perspectives on growth implications and the earth's resources and energy
- a review of existing curricula in relevant subject areas

Student Perspectives

Several questions guided our research on student perspectives:

- How do students think and feel about growth issues?
- What do they perceive as problems?
- Do they, or can they, understand the interrelationships among and within systems?
- Do they, or can they, understand the concept of "limits within a system"?
- What concepts, metaphors, analogies, examples, and experiences do students use in thinking about such things?

- What competencies do students already have for working on systems problems, ecological problems, growth problems?
- What competencies are students capable of developing?
- How do students differ in their approaches as a result of grade level and rural/urban/suburban background?

To obtain information on these questions, we interviewed ninety students from grades seven, nine, and eleven, and from schools in urban, rural, and suburban settings.

Curriculum Review

The fundamental question we asked in reviewing materials was:

- Do existing curricula provide students with the necessary learning experiences, perspectives, conceptual framework, and information to deal with growth implications and the long-term cultivation of the earth's resources and energy?

Before we could begin this investigation, we had to define criteria for appropriate and adequate curricula. These criteria fell into two categories: pedagogy, and content and goals.

Pedagogical Criteria and Curriculum Goals

To define pedagogical criteria, we drew first on our own experience in curriculum development and evaluation and identified five major components of an effective curriculum:

It takes as a starting point the skills, interests, attitudes, knowledge, and experience of the students for whom it is designed.

It provides active and engaging experiences that start with students' current interests and skills and stretches them to meet new challenges and goals.

It provides a framework that helps students conceptualize new experiences and deal with feelings that are evoked.

It affords multiple modes of experience, because students have different styles of learning.

It supports teachers by providing help in developing teaching skills and evaluation models suited to the subject matter and to the students' needs and interests.

To define criteria for the goals and content of curricula, we drew on the work of scholars and practitioners in relevant fields. As a first step, EDC convened a Planning Conference on October 3, 1975, at which participants were asked to identify important areas of concern for education.

Conference Participants

Consulting Scholars

Dr. Elise Boulding, Professor of Sociology, University of Colorado (Boulder).

Earl Craig, Chairman, Black Caucus of the Democratic National Committee, and Director of the Urban Coalition of Minneapolis.

Dr. Herman A. Daly, Professor of Economics, Louisiana State University; steady state theorist.

Dr. Norman Faramelli, Board Member, Bread for the World; ethicist/activist, concerned with Third World development, and energy and food issues.

Elizabeth and David Dodson Gray, ethicists/writers; authors (with W. F. Martin) of Congressional Staff Report for hearings on "Growth and Its Implications for the Future"; EDC senior consultants for the project.

Hazel Henderson, Codirector, Princeton Center for Alternative Futures, and consultant to the Office of Technology Assessment; economist/activist.

Dennis Meadows, Project Director for *The Limits to Growth* project; systems analyst.

Frank M. Potter, Congressional Committee Counsel; active in growth issues in Congress.

Robert Sweeney, author, teacher, systems analyst.

Carrol L. Wilson, technology management, MIT faculty; member, executive committee, the Club of Rome; wide experience ranging from AEC general manager, to UNEP and OECD, to current director of an international Workshop of Alternative Energy Strategies.

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Other resources for defining content and goals criteria included: telephone calls and on-site visits to numerous teacher-educators and resource centers; relevant papers such as Perelman and Bergquist's *Growth and Education;* Perelman's *Developing an Ecological Curriculum for "Sesame Street";* the report of the Belgrade conference of October 1975; *Intercom #77* of the Center for War/Peace Studies; and several books including the Dodson Grays' *Growth and Its Implications for the Future,* Meadows's *Limits to Growth,* and Schumacher's *Small Is Beautiful.*

From these resources we developed the following list of general goals for secondary school curricula dealing with growth implications and the earth's future. Students should develop:

- elementary knowledge and conceptual competency in "earth husbandry"
- an understanding of the finely tuned interrelationships among natural and social systems
- the ability to analyze what constitutes growth-effects and growth restraints—i.e., what aspects of a given kind of growth raise problems for global survival and what conditions limit growth
- skills for understanding and dealing with problems of a systemic nature
- a multidisciplinary perspective for considering the values, priorities, and implications for both the natural and social spheres that underlie decisions about resource development and use
- competence and willingness to sort through the predictions, data, and values presented to them in everyday life in order to evaluate conflicting positions and proposals for action
- competence and willingness to pursue life styles and careers that support a sustainable social and economic life, and to approach decisions with an awareness that one's own actions can have large-scale effects

The resulting competency preparation should enable students to be better informed citizens and to make enlightened decisions; and it should motivate significant numbers of students to enter careers related to the long-term cultivation of the earth's resources and energy. While jobs in numerous fields are declining, jobs involving earth science, environmental concerns, and engineering are becoming increasingly available.

What to Teach

The next step—moving beyond general goals to the classroom question of what and how to teach—poses for this subject area a special sort of dilemma, described well in the following extract from *Intercom #77*.

The Teacher's Dilemma*

Suppose there is a community of people who live on the edge of a cliff, where the view is breathtaking. People keep moving into the community and building homes along the cliff edge. One day a resident of the community makes some tests and comes up with some distressing news. If any more homes are built along the cliff the whole face of the cliff may break off and take the community along with it. It's a long way down and that will *really* be breathtaking. Nonsense, say some of the other residents, the rock is perfectly solid and you can safely continue to build new homes. In fact, the prosperity of the community depends on it. There is thus a lively debate. And it isn't just an argument over trifles. The very existence of this group depends on the judgments that are to be made.

Suppose you are a teacher in this cliff community. How will you educate the children about this problem and issue? Will you warn the children to leave the community? Will you consider your duty done if you inform them of the different positions being argued? Will you suggest that they make up their own minds and then join in the debate? Will you set an example by making a decision to build yourself a house (a) on the cliff edge or (b) safely to the rear? Will you decide that the matter is too profound, too disturbing, or too complex for children to encounter?

---

*Reprinted from *Intercom #77*, "Explorations in the Emergent Present," by Andrea Karls and William Nesbitt, published by the Center for War/Peace Studies, New York, 1975. Used with permission.

The world community may be in a situation like this. Poised on a cliff that may be very durable—or that may give way. Technical experts disagree: Continued growth will bring disaster, say some; continued growth will bring solutions, say others. Still others argue for selective growth—some there, none here.

The dilemma for those who teach the young is—what and how do you teach about momentous issues, world developments that may impinge in very direct ways on all our lives, *when the "best minds" cannot agree on the significance of what is happening.*

Should the schools amplify and broadcast the warnings of "sentries"? Every society has its warning systems. The sentries are those who guard the frontiers (of time as well as space). Watch out! they call. And the schools might take up those warnings, spread them more widely, explain them. Those who wrote *The Limits to Growth* are sentries. Shall we pass the warnings along?

One solution, of course, is to pass the warnings along but "balance" them with counterarguments. . . .

If one does the balancing act—A says this but B disagrees—you may end up with students who know in a cold dispassionate way that somewhere out there a sentry is shouting warnings—but they don't much care. You have alerted them but comforted them at the same time. And they have other things on their minds.

There is no beautifully wrapped solution to this dilemma. Individual teachers will solve it (by commission or omission) in their own ways. But we can probably agree on some minimal functions distinctively within the purview of schools. First, it probably is appropriate that the schools pass along the warnings of the "sentries." This is the kind of information that must be freely distributed, *even if it turns out eventually to be invalid.* The schools are not in a position to judge the good sense or the veracity of the sentries. But we'd all better know that there are cries of alarm on the outskirts.

Second, the schools can educate the young to comprehend the reason for the alarm *in as sophisticated a way as possible.* This means, in our day and age, that students must learn the pertinent technical concepts. It is not enough to hear the simple cry of alarm about growth. Various kinds of growth must be understood in some technical sense. The mass media are good transmitters of alarm; they are not very good at technical details. That is something the schools can do.

Third, the classroom with all its drawbacks provides an arena in which students can "play" (in the best sense of that term) choice-making and problem-solving roles. Play is one of the important ways in which primates learn, human primates included. At the present time choice making and prob-

> lem solving are beginning to assume new forms. The schools can invite the young to play choice-making roles that are true to the emerging forms in the larger society. That means, among other things, the use of computer models of the future, and ways of forecasting that make explicit assumptions about how various factors interact and that enable the testing of various alternative policies.
>
> Finally, the classroom is a place where feelings and values and ethical stances can be brought to the surface and examined.

This statement seems to us not only to present the dilemma, but also to summarize well the general areas curricula should cover:

- the "warnings" of sentries, as well as the counter arguments
- the pertinent technical concepts for comprehending the reason for alarm
- classroom opportunities to practice choice-making and problem-solving roles, and to develop skill in these roles
- classroom opportunities to explore feelings, values, and ethical stances

Curricula should also help students to learn how issues come to be identified as problems, and to develop the ability to identify and assess new problems themselves.

In our research, another important element surfaced: students need to study human resourcefulness, and they need to develop the skills and learn about the conditions that enable people to respond actively and creatively to critical problems. We address this issue in the conclusions to this report.

Underlying Concepts

What is the specific body of perspectives, information, technical concepts, problem-solving and choice-making skills, feelings, values, and ethical positions that a curriculum should address?

Perelman's work, the Belgrade conference resolutions, and our own planning conference led us to the following position:

> An education program in growth implications should bring together in a unified learning experience the perspectives of the earth sciences and the social sciences. This combination

> of perspectives is essential to understanding the holistic* nature of the growth-and-resource issue, and distinguishes this curriculum from standard biology, ecology, geology, or social studies curricula.
>
> In addition, pedagogical strategies of the program should be conducive to the attainment of a systemic perspective.

The concepts developed as criteria for our research follow. The definitions and descriptions of the concepts were written by Elizabeth and David Dodson Gray.

What Is a System?

A system is a clearly identifiable portion of the universe
which we isolate and discuss apart from the rest of the universe.
On a human scale,
our body's circulatory system is one such system;
it consists of our arteries, our veins, our heart,
and the blood that flows through them.
The earth with its continents, its oceans,
its atmosphere, and its peoples is a much larger system.
On a very large scale,
the solar system is a system,
and consists of the sun and its planets.

A system consists of interacting parts that
function together
in ways that cannot be understood fully by
studying only the system's parts.
A person is a system, for example.
All the aspects of human personhood—such as the body,
the mind, the emotions, and whatever else—
are in continual interaction one with another in time.
Yet any of us as a person cannot be understood fully
simply by studying these parts which,
all acting together, make us who we are.
Similarly, the solar system
or our body's circulatory system
cannot be understood simply by studying their parts.

Or, stating the same thing a little differently,
a system has a characteristic way of functioning

---

*holism: the view that an organic or integrated whole has a reality independent of and greater than the sum of its parts. (*Webster's New World Dictionary*, 2nd ed.)

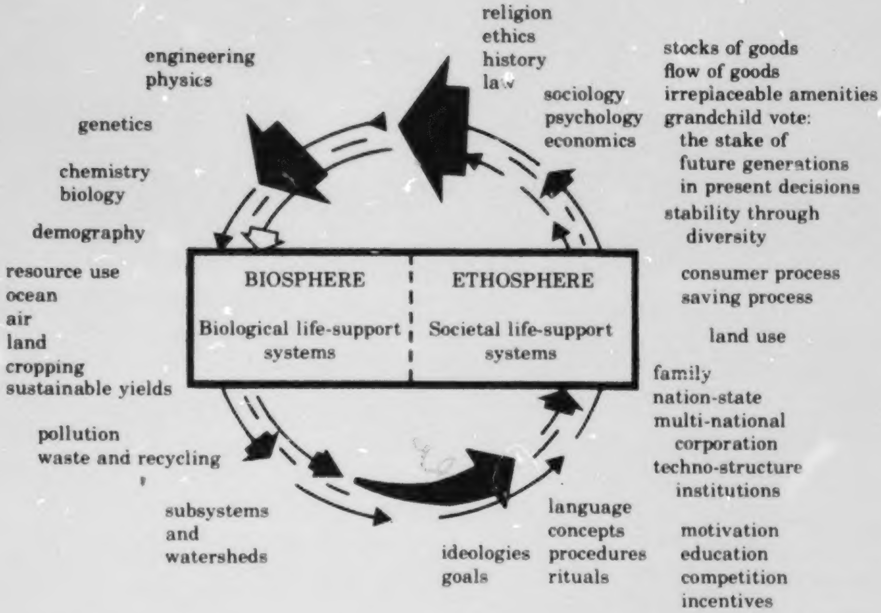
that arises out of the INTERACTIONS of its component parts.
We can see this in the family, another example of a system.
All the parts of a family—wife and husband, parents and children,
humans and pets in their home—
are in continual interaction one with another in time,
affecting the behavior of one another even when
they are apart at work or at school or on a trip.
Each family living together is continuously evolving patterns
of working things out as a family.
What is evolving as "the family's life" is not visible simply
from seeing the separate family members;
one must see them "being the family"—interacting.
What we call family life is a system
with a characteristic way of functioning,
which arises out of the interactions among family members.

The Two Great Systems: Biosphere and Ethosphere

We find systems everywhere.
The planet earth sustains all life through many life-support systems—
such as the oxygen/carbon-dioxide cycle,
in which solar energy causes green plants to give off oxygen,
which animals and human beings breathe in and
convert to carbon dioxide,
which we then breathe out for use by plants; thus, we are
in continual interaction with green plants over time.

Similarly, the need of all living beings for water is met by
the ocean/cloud/rain/snow cycle, which constantly
redistributes water in its various forms.
All life on this earth is sustained within vast natural life-support
systems such as these, which together comprise what we call
the BIOSPHERE.

Society, like nature, is full of interrelated systems.
Our libraries, schools, languages, laws, ways of buying and selling,
all are examples of the many interacting networks,
or systems, we humans have created
to organize the ways we relate to one another.
All systems that maintain and transmit the human cultural ethos
make up what we call the ETHOSPHERE.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grandchild vote:
the stake of
future generations
in present decisions
stability through
diversity
BIOSPHERE
Biological life-support systems
ETHOSPHERE
Societal life-support systems
resource use
ocean
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sustainable yields
consumer process
saving process
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goals
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concepts
procedures
rituals
motivation
education
competition
incentives

The Interrelatedness of Biosphere and Ethosphere

The biosphere and ethosphere do not exist apart from each other; they are continually affecting one another.

The automobile is an example of this interaction.
The auto originated in the ethosphere (human minds as ideas and designs).
It is made of raw materials taken from the biosphere.
The assembly-line is an invention of human organization (ethosphere).
But the energy (human and fuel) that powers the assembly-line comes from the biosphere.
The widespread use of cars made possible the suburban way of life (ethosphere) even while it has produced pollution in the biosphere.

Characteristics of the Behavior of Systems

Delayed and Displaced Effects (in time and space)

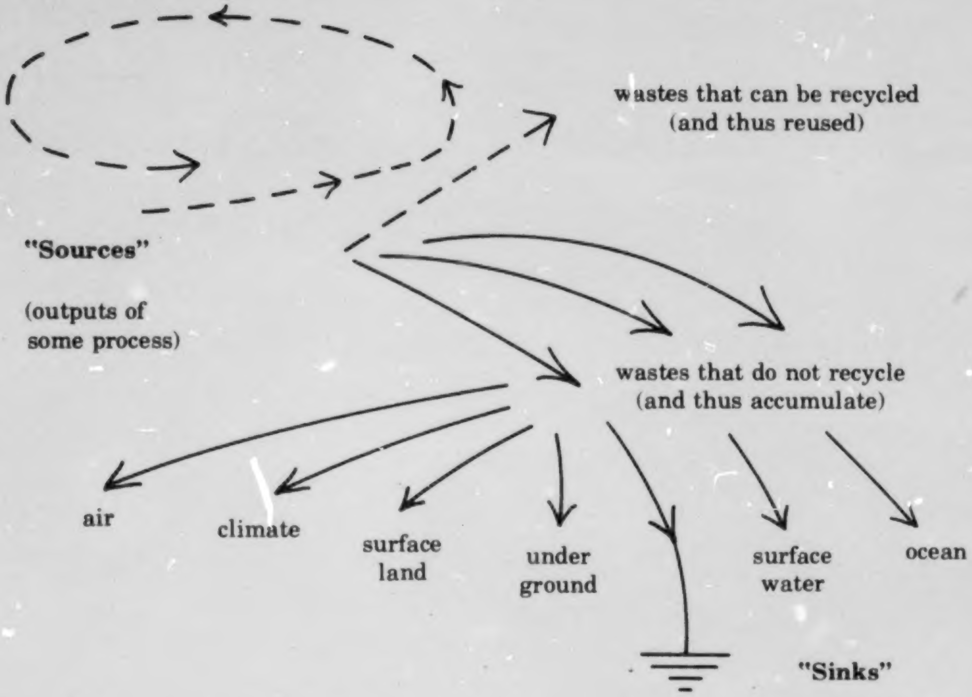
When something new is inserted into a system,
all that changes may not be immediately apparent
because interactions within systems are complex.

DDT is an example of something whose effects were
widely displaced as a result of various complex systems
interacting to affect remote parts of one another in ways
that we did not understand well enough to anticipate.
Immediately apparent was DDT's effectiveness in
killing insects and reducing insect-borne diseases.
What was not immediately apparent was that DDT also had
many other effects.
It killed birds (by removing their food supply).
It washed into rivers and was carried to lakes
and oceans far away
where it became concentrated in the bodies of fish.
One very distant effect was upon bald eagles who feed
on such fish.
The DDT in those fish began to eliminate the bald eagles
as a species by making their shells too fragile to
be hatched.

Another look at the auto shows that displaced and delayed effects
occur in the ethosphere too.
The technological change from horse to horseless carriages
contributed to many unanticipated developments:
the growth of the highway system,
the conversion of farms and orchards into suburbs,
the decline of an extensive urban and interurban trolley
system,
the decline of many urban centers,
the development of auto-oriented patterns of consumption
(symbolized by fast-food chains and shopping centers).

Displaced effects and delayed effects
go beyond our usual understandings of cause and effect.
Displacement of effects to more remote times and places
is caused by system-modifications,
produced by the accumulation in a system of something new.
This means that, when the biosphere is seen as a whole,
"There is no *away* to throw things to" (Garrett Hardin).

Any substance
introduced into a system (at some source)
is carried by natural processes
to some collection point or points (sink) and,
if it does not fit into the natural recycling processes,
it becomes a "clog" in that particular sink.


wastes that can be recycled
(and thus reused)
"Sources"
(outputs of
some process)
wastes that do not recycle
(and thus accumulate)
air
climate
surface
land
under
ground
surface
water
ocean
"Sinks"

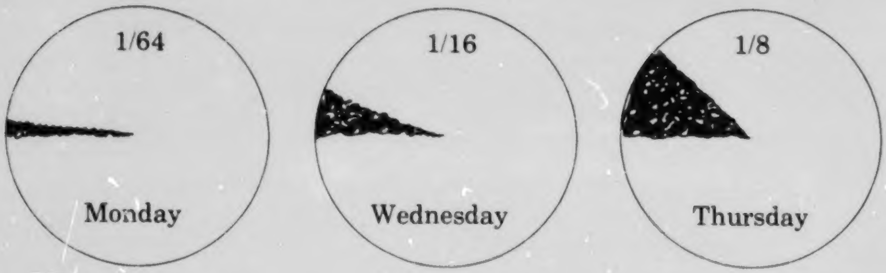
The Flow of Substances Into Some Part of the Environment .

Exponential Rates

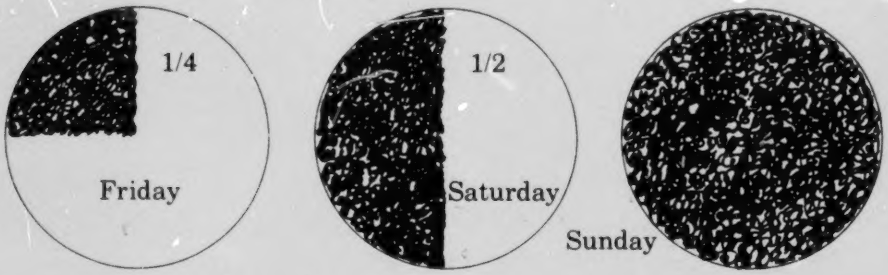
Systems are frequently characterized by rates of change (growth or deterioration) that are different from our usual perceptions of growth or deterioration.

We are accustomed to experiencing growth that takes place
by addition,
as when we add years to our lives
or miles to a journey.
But when we watch our bank balance grow by compound-interest,
we see a growth-rate that multiplies (by the interest rate)
rather than adds.

The effect of growth rates that multiply (rather than add)
can be seen in a lily pond that is 1/64th full on Monday.
The lilies in the pond double daily.



By Thursday the lily pond is only 1/8th full of lilies
and a lily crisis still seems remote.
But by Saturday the pond is half-covered with lilies.
And Sunday the pond is full of lilies,
even though the Monday before the pond was 63/64ths empty.



Growth rates that multiply (or divide)
rather than add (or subtract)
are called EXPONENTIAL rates.
The important feature of exponential rates
of growth in systems
is that results that are physically remote
and psychologically remote
can be nonetheless very close in time:
The lily pond was only half full the day before it completely filled.

Limits

Systems have limits that constrain the behavior of which
they are capable.
System limits are built-in bounds that are inherent in
a situation.
A human being's physical constitution and personality structure
are SYSTEM LIMITS inherent in being that person.
But we are accustomed to thinking about limits in quite a
different way:
as PHYSICAL LIMITS,

limits that are essentially outside of us and
apart from systems of which we are a part.
We perceive these limits as being like a wall or cliff;
they restrict us and pose a challenge to us.
Our experience with these limits is that they may be like
sports records—
with skill, diligence, and luck you may find a way
to penetrate a physical limit.

When we press against or through physical limits in a system,
to a point the system is resilient and accommodates—
within its system limits.
However, system functioning is usually somewhat impaired.
(Body temperature is an example of such a system limit,
as anyone who has run a high temperature or suffered
exposure to cold knows.)

Beyond certain definite system limits, a threshold
is reached.
Thereafter system resiliency diminishes very rapidly.
(Human temperature control does not self-correct
above 107° or below 89°.)
When you approach the system limits,
the system becomes less and less capable of sustaining
or restoring itself.
We need to stop thinking about environmental limits of
the biosphere systems as somehow like the sound barrier.
Human society is not a supersonic jet that, when properly
designed, can crash through these environmental-system limits.
The concept of spaceship earth has summed up the recent
understanding that the limits of our earth system
are inherent in the structure of the earth itself.

The Dynamic Behavior of Systems

Systems Change Over Time

Some systems change very little with time;
our solar system, because it is isolated from all external
influences, does not change perceptibly within the lifetime of
a casual observer.
Other systems remain unchanged with time only if
they are continually being repaired by external influences.
Our earth and its peoples require energy to sustain their life
and to grow.
Without energy, human life and the earth system would change rapidly.

Energy

Energy is the capacity to do work.
But as energy is used, it becomes
unavailable to do further work.
The energy in a piece of coal becomes heat when the coal is burned,
and that heat soon passes to the atmosphere and
then is lost from the earth to outer space.

Entropy

A system like the earth may secure energy it needs
by changing ordered portions of itself
(for example, clusters of carbon atoms in lumps of coal)
into disordered fragments
(soot, ash, and molecules of carbon dioxide)
that wander aimlessly through our atmosphere.
In order to get the energy it needs to survive
a system such as the earth may find it necessary continually
to disorder a portion of itself (its coal fields).

This process of feeding on its own internal order
represents a serious threat to the continued survival
of the traditional behavior of the system.
An earth without coal or other energy-yielding ordered atoms
might become an earth without people.

ENTROPY is a term that expressed the increasing disorder
associated with the change of available energy
into forms in which it is unavailable.

Unless an external energy source restores order in systems,
they move toward increasing entropy and disorder.
Thus if an external energy source (such as the sun) is available,
one low entropy material (such as wood) may be growing
and increasing in quantity
at the same time that another low entropy material (such as coal)
is being changed into disordered fragments of high entropy.

Dynamic Equilibrium

Sometimes the elements in a system interact with one another,
fundamentally disrupting the balance of part or all of that system.
In the world today changes in mortality rates
(causing exponential rates of growth in population size)
and changes in per-capita consumption rates
(causing exponential rates of growth in both resource depletion

and pollution)
threaten to disrupt the balance of the whole system.

Elements in a system can interact with one another in ways
that do not destroy the balance of the system.
The water/clouds/rain/snow cycle and also the exchange
of carbon-dioxide and oxygen between plants and animals
are examples of systems that are constantly changing
and yet always remaining balanced in DYNAMIC EQUILIBRIUM.

The succession of day and night and the continual passing of the seasons
(due to the earth's turning on its axis and
rotation around the sun) are other examples of changes in
a system that do not disrupt but are features of the system
and its balance.

In the ethosphere, the constantly shifting positions of players
on a hockey or basketball team express the dynamic balance
between offensive and defensive play.

The framers of the United States Constitution envisioned the
Executive, Legislative, and Judicial branches of government
in dynamic balance,
preventing any portion of the system from having too much
power over the whole.

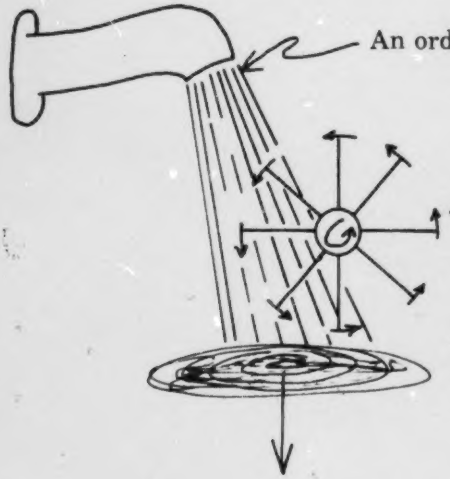
Dynamic Balance in the Biosphere

In the biosphere dynamic balance is maintained by
energy that comes originally from the sun
and continually reassembles disordered atoms into
ordered structures.
The materials necessary for life are thereby
cycled and recycled by this solar input to the biosphere.

Unless a system secures an external reordering influence
from an external energy source,
the drift toward disorder and deterioration in the system
will ultimately destroy its traditional behavior.
A house is an example of a system that a carpenter can repair.
Garbage on a compost heap can be changed by the sun into a tree.
The carpenter and the sun are examples of external energy sources
that restore order by putting energy into a system.

The restorative processes always require
infusions of energy that come
directly or indirectly (as with coal) from the sun.

It is the sun's energy that powers the natural processes
which recycle (reorder) waste matter into low-entropy,
reusable forms of matter.
Without conversion of energy,
a large system like the earth would not maintain
its dynamic balance;
traditional behavior (including alive and happy people) would stop.



An ordered stream of water has available energy

and does work

But the water goes down the drain
to disorder,
where it can no longer do work for us.

We must exercise conscious regard for slowing the entropic
movement toward disarray and dissipation of
the energy and materials necessary for life.

Industrial societies have not in general been set up
to recycle waste materials,
or to make further use of otherwise wasted heat-energy.
The continued availability of the energy and materials necessary
for life
has been viewed as a series of problems that are
economic and political, social and technical.
But fundamentally the availability of energy and materials
is an entropy problem.
It is the problem of getting the most accomplished
with limited amounts of available energy,

using it to cycle and recycle what is finally a fixed quantity of various materials.

Our earth system is a cascade of cycling and recycling, driven by the reordering action of the energy of the sun. Traditional behavior of the earth system is endangered when we disorder our environment at a rate in excess of the speed at which the sun reorders it.

Ways Systems Adapt (Adjustment Mechanisms)

There are a number of ways
in which human societies adjust and adapt
to changes either within a society
or in society's relationship to its physical environment.

Market-and-Price Adaptation

The market-and-price system is one way societies adjust what is needed (demand) to what is available (supply). Adjustment comes from changes in a universally understood communication signal, price. The price varies according to what amounts buyers are willing to offer and what sellers will take.

Higher prices reward users for using less of what is scarce and for substituting things that are less scarce, hence less expensive.

A great advantage of the market-and-price system for day-to-day adjustments to changes is that—unlike laws and government regulations—price changes can be made moment-by-moment, in an extremely decentralized fashion, according to the latest changes in the needs and plans of those with most at stake, the buyers and sellers.

However, because changes in market price are inadequate for certain purposes (namely, dealing with depletion, with pollution, and with the fairness with which scarcities are distributed) the market-and-price system has been supplemented at many points by other adaptive systems in order to improve or direct its functioning for what is perceived to be a more socially desirable purpose.

For example, by legally setting resource depletion rates and resource prices, the market in a resource can be adapted to make recycling profitable.

Political Adaptation

Political systems set out the broad frameworks within which individual and institutional decisions can legally be made.
It is the responsibility of the political system,
in its local, regional, and national parts,
to identify issues,
enact laws,
set standards,
and then adapt both enforcement and the rules themselves
as situations change.
As the perception of reality changes, the political system adapts.

Legislation about the environment is an example of
a new issue being identified,
new laws passed,
a new agency of government being established,
and new standards beginning to be set,
so that individuals and various sorts of organizations are
required uniformly to adapt their behavior to these standards.

Social Adaptation

Outside of the formal governance system of politics is a
wide range of social institutions—
the family, school, religious community, communications
media, place of work, recreation, the world of sports, etc.—
that both shape and reflect
the ways in which people see themselves and their world,
and therefore influence how people behave.

Individuals and society adapt through changes
in "consciousness," "public opinion," "values," "life styles,"
"images of human nature," and "visions of the future."
All the social controls that shape human behavior more closely
than the broad and general framework of laws,
belong to the social system and facilitate social adaptation.

Knowledge-and-Technology Adaptation

Certain institutions within society specialize in adaptive
problem solving.
They conserve, apply, and adapt existing knowledge,

and seek to develop new inventions and techniques. They also help organize our understanding of ourselves, our world, and our future, as well as the problems we face and are trying to solve.

The worldwide decrease in mortality rates (and resulting population growth) resulted from widespread implementation of new technologies improving human survival. Likewise, our perception of the extent of current population problems has also resulted from new technologies for gathering and organizing information.

Biological Adaptation

Biological processes eventually restore ecological balance to the biosphere when it has been disrupted. These adaptive processes include mutation and extinction.

Once disrupted, the biosphere does not necessarily return to its previous state. For example, after the Ice Age certain mammals like the wooly rhinoceros were extinct and not a part of the subsequent balance.

Although the biosphere will always adapt, it may not be restored to a state that humans want.

For example, human use of fossil fuels might proceed at such a rate as to increase the carbon-dioxide content of the atmosphere to a point where humans could no longer breathe, but the system would still adjust. The human species would diminish while plant growth—which depends upon an abundance of CO_2 for photosynthesis—might flourish until a new ecological balance was reached.

Evolution is, in fact, the cumulative result of this biological adaptation by species and systems.

Ways of Thinking/Behaving

Paradigms

People make decisions and create institutions on the basis of their models or theories about the world.

Before the time of Columbus, the average person in Western Europe conceived of the world as flat. This mental model affected what navigation on the high seas people thought was possible.

We have mental models about how people and society function: "survival of the fittest," Horatio Alger, "the profit motive," and Adam Smith's "Invisible Hand" are mental models that affect how many of us think and what we think is possible.

PARADIGMS are basic and inclusive mental models that organize the way we view our world. Paradigms organize vast amounts of experience into patterns that "make sense" for us:
our world view.
They shape our understanding of experience
and help us anticipate what is possible.
Thus, paradigms influence *how* we experience.

As comprehensive systems of understanding and perceiving, paradigms do not undergo substantial change easily.

The classic example of a paradigm shift was the change from the Ptolemaic to the Copernican world view. In the Ptolemaic system, the earth was viewed as the fixed center of the universe, with the sun and other astronomical bodies moving about it. In the early sixteenth century, Copernicus theorized that the earth and planets move instead about the sun. His view was gradually accepted over the next century. This new paradigm caused fundamental changes in how the world and every system in it was viewed.

After World War II, Americans came to view their world in terms of a paradigm, called "The Cold War." This became the dominant world view through which Americans experienced, interpreted, and responded to the actions of all other nations.

Perhaps a new paradigm shift is occurring as people begin to think of their world as "spaceship earth."

A Recurrent Dilemma: Commons Behavior

The dilemma that Garrett Hardin has labeled "The Tragedy of the Commons"
arises when individuals are confronted with deciding
how to use a limited resource
(such as the grazing land in a common),
and each individual is free to receive all the BENEFITS from

his actions
(such as adding additional cows to graze on a shared common)
but the COSTS that result (in this example, overgrazing)
are distributed among all who share the common pasture.
This imbalance between who received the benefits and costs leads
"inexorably" to the destruction of the common resource,
hence Hardin's use of the word "tragedy" to describe a seemingly
inescapable outcome.
That effects are displaced (in time or space) often obscures
the responsibility of each individual.

The phenomenon recurs frequently.
Each nation taking food from the oceans
gains from adding additional ships and new technologies,
but speeds destruction of the world's fisheries.

Each company or householder dumping pollutants into a river
gains from disposing of additional wastes,
but the river is ruined by the cumulative actions of all.

This dilemma might also be entitled "the tragedy of the
paradigm of individualism," for the well-being of the individual
cannot be separated from the systems (commons) of which
he is a part. When the systems are diminished or destroyed,
the individual is also hurt.

Choice Perceptions (Trade-offs)

The choices before us are never isolated choices.
They are really choices that exist within the highly interacting
biosphere and ethosphere systems.
They are thus system choices. They will be made more wisely
if we make them with system models in our heads.
This new way of recognizing the complexity of trade-offs
we are calling CHOICE PERCEPTIONS.

Some choices may seem to involve either/or choices.
For example,
if we stripmine Western grazing land, we will be choosing
the "energy product" of that land instead of
the "food product" of that land.
In later years, when food is more scarce, will we wish that
we had considered and followed more thoroughly the implications
of the trade-off we made?

Perhaps when we get further into holistic thinking,
it will become evident to us that thinking in terms of trade-offs

or either/or choices is a part of the old paradigm of
seeing parts instead of the whole.

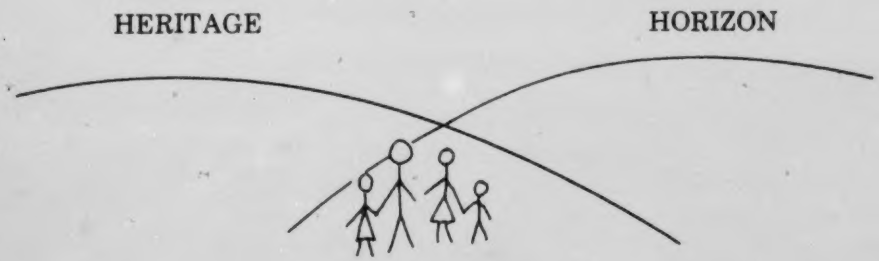
Possibly when we all learn to think better in systems,
we may decide that
the only good choices are the ones that are good for the
whole dynamic system.

Integrating Past, Present, and Future (200-Year Present)

One of the functions of mental models
is to provide a frame of reference for our thinking about
the present,
and such a frame of reference must incorporate
the flow of time in which all systems interact.
Often time and our experience of the continuous flow of change
are left out of our mental models, and we think of life
as a succession of separate snapshots, each of a different "now."

But it is more accurate to think of ourselves as always living
where past and future intersect, where heritage and horizon meet,
for our present choices grow out of past paradigms,
and out of the decisions and the options they have created.
We are now creating for our children and grandchildren
the opportunities and limitations with which they will be confronted.
For example, using up the earth's nonrenewable fossil fuel
resources is a "forever" choice for our children.

"THE GRANDCHILD VOTE" is a term used by Newell Mack to refer to
the stake of future generations in the costs or benefits
of present decisions.



A View of Things That Is Future Responsive

Sometimes we view things "in past tense"—accounting only for how they got to be the way they are now. This is like looking at the wake of a boat: it tells you how you got to here.

Other times we view things "in present tense"—stating that this is how things are, period. We may also describe how things work or interconnect, but not how they came to be here. Much science is "present tense."

Our view of things is FUTURE RESPONSIVE when that view includes awareness of and responsibility for how things will be in the future. This view acknowledges that our future is going to be shaped partly by things that have already happened (and can't be changed),
partly by things we are now doing/not doing, choosing/not choosing,
and partly by future events that aren't accessible yet but will become so later.
Something is future responsive when it presents ourselves as active in the process of creating our futures.

There is another view that might be called "future irresponsible," which views us as victims of our future, a future that is viewed as beyond our control. This is what some people mean when they call someone a doomsday predictor.

Thinking, teaching, and action are future responsive when they make clear the place of present and past events in affecting what will and will not be possible in the future. A future responsive emphasis makes prominent our human role as agent or doer. It calls for our active participation in shaping history as an ongoing process, and usually seeks to anticipate and be responsible for outcomes resulting from our actions.

The Two Studies

Having defined the elements we would look for in curricula, we then turned to the two research tasks: (1) exploring student concepts, skills, and attitudes; and (2) reviewing existing curricula. Chapters two and three of this report describe the procedures and findings of these two tasks.

Although we reviewed a vast amount of carefully selected material and interviewed almost 100 students, we wish to make clear that neither study could be statistical in nature. Therefore, the studies are basically exploratory. We have attempted to be as rigorous as possible in reporting and presenting our findings. By careful study of a range of students and a number of curricula, we hoped to obtain a valid and useful sense of students' views and abilities, and to determine what existing curricula offer them.

Student Perspectives: Evaluation Findings

Approach

A major thrust of our work was an exploratory study of student understandings, attitudes, and skills regarding growth and survival issues. By identifying student capabilities and apparent needs in these areas, we hoped to inform the design of programs that can effectively promote interest in and understanding of these issues.

Our formative evaluation study was organized around the following questions.

Student World Views

- How do students think and feel about growth issues?
- What do they perceive or not perceive as problems?

Conceptual Understanding

- Do students understand concepts such as system, dynamic behavior of systems, limits, cycle, and adjustment mechanisms?
- Do they understand the interrelationships among and within systems?
- Do students view the past, present, and future within a systems perspective?

Methodology

- What competencies do students already have for thinking about problems of systems, ecology, and growth? For example, do they already have skills in the areas of problem identification, data gathering, analysis, design, and evaluation that we might build upon?

Grade and Site Differences

- Do students differ in their approaches to thinking about problems of systems, ecology, and growth as a result of grade level and/or urban/rural/suburban differences?

We were particularly interested in learning what concepts, metaphors, analogies, examples, and experiences students used in thinking about these subjects. We wondered if there would be differences according to grade level and type of community.

To gather this information, we conducted interviews with a total of ninety students drawn from schools in rural, urban, and suburban areas.

Number of Students at Each Grade Level

	Seventh	Ninth	Eleventh
Rural (one school)	10	10	10
Suburban (one school)	10	10	10
Urban (two schools)*	10	10	10

A total of forty-three boys and forty-seven girls were interviewed in small groups of no more than three, and occasionally on an individual basis. Approximately 10 percent of the sample came from a minority background.

Semistructured, open-ended interview questions were drawn up (see Appendix) and trial-tested with students at each grade level. Based on trial outcomes, the questions were revised prior to working with the actual study sample. All interviews were tape-recorded with the interviewees' permission, and later transcribed in preparation for analysis.

We deliberately chose the open-ended interview format to gather data on current student thinking and concerns. This format allowed us to probe responses to our questions, and gave students a chance to offer responses we might not have thought of. Our purpose was truly exploratory in this sense: we were not concerned with the precision of numbers derived from responses to a fixed set of questions but rather with seeing the range of ways in which students were thinking about our questions.

Students were allowed to bounce responses back and forth within the framework of our interview schedule. Sometimes we learned more from one student group than another, sometimes more from a single student within a group than from that particular small group as a whole. This process made tallying difficult, so that our figures must be taken only as estimates. However, we believe the information presented within the body of this report represents fairly the general thinking of the students with whom we talked.

In the next section, interview data are discussed with excerpts from actual conversations. Throughout, the interviewer's primary question appears in bold print. Students are identified as S_1, S_2, S_3,... for any single excerpt and the interviewer as I.

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*In the urban sites, seventh graders were drawn from a center city school, ninth and eleventh graders from a large metropolitan high school.

Data Base

Student World Views

How do students think and feel about growth issues?
What do they perceive or not perceive as problems?

Student Views of the Present

About three-quarters of the students in our sample (65/90) had positive attitudes about the current state of the world but felt we faced a range of problems. Only about one-third of the students said without reservation that the earth generally was a good place to live.

In general, students seemed to rank the critical problems facing the earth today as:

- violence and war
- overpopulation (which they saw leading to a lack of food and space)
- pollution

Occasionally, students mentioned other problems such as the (mis)use of natural resources (e.g., oil), rising prices, and famine. But such responses were too infrequent to merit special significance.

What do you think are the worst problems facing the world today?*

Violence and War

Urban, seventh

S_1: People snatching pocketbooks and stealing, robbing, mugging, pickpocketing, and everything.

S_2: Breaking and entering.

S_1: Killing people, robbing.

Rural, ninth

S_1: Killing is.

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*For a listing of student interview questions, see Appendix.

I: What would *you* say?

S_2: Killing.

I: What's the second worst problem?

S_1: You know, all the crime put together—rape, murder, robberies.

Rural, eleventh

S_1: Well, with all these major countries building all these atomic missiles, you know, just any one person—well, not really—but all you got to do is just push one button and everything's gone. If one person pushes a button and you send the missiles over to Russia, they push a button and send them over to the U.S., there would be nothing left. And it could happen any time, you know.

I: So you say that war is one of the biggest problems?

S_1: I think that everyone is worried about it.

Overpopulation

Suburban, seventh

S_1: Overpopulation. I mean, everyone is having more and more children, and that's including dogs and cats. Like my parents have three children and most parents have three, four, or five children. I mean, if it keeps on going up that way, then soon the families will get bigger . . . and there will be more people in the world. That's the biggest problem. We'll soon run out of space. . . .

S_2: There's six people being born for every one person dying.

Suburban, eleventh

S_1: Lack of food: that's the basic thing for life.

I: What causes lack of food?

S_1: Overpopulation.*

Pollution

Suburban, ninth

S_1: The worst problems today, the problems that will affect everybody, I guess, would be the environment. I think we have to have a good environment.

I: How has the environment gotten to be bad?

S_1: Through pollution. Through the wastes.

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*Students see problems with regard to food as stemming from overpopulation; issues of distribution were rarely mentioned.

In comparison with suburban students, urban and rural students more frequently expressed concern with violence, crime, and the use of drugs and alcohol. Suburban students seemed more concerned with the problems of pollution and overpopulation. Later in this report, we show how rural and suburban students' predictions for the future were consistent with their views of the world today, while urban students' perspectives changed as they looked to a far brighter future for themselves and other people.

Impact of Science and Technology

In general students expressed positive attitudes about science and technology. They credited scientists with the development of an impressive and extensive communications system and with many advances in the fields of medicine and agriculture. However, about 10 percent mentioned negative delayed or displaced effects of technological impact, such as the effects of spray cans on the ozone layer, the unanticipated side-effects of some drugs, and the increasing level of pollutants in the biosphere.

Two eleventh-grade students noted that technology has made individuals more dependent than their ancestors were.

> **What effect do you think technology has had on the earth's people?**

Suburban, eleventh

S_1: It's to the point where you don't have everyone working to keep themselves going. It's to the point where people wouldn't know how. I don't know about you, but I know I couldn't go out and be self-sufficient. It might get to the point where no one is going to know how some day.

I: So you feel technology has removed people from knowing how to survive?

S_1: It's made us more dependent on other things.

Rural, eleventh

S_1: In the olden days they didn't have, you know, any gas or energy or any of these problems. . . . We like to look ahead, but now we . . . depend on what everybody else makes, like gas and energy, and we depend on people, too. So we're depending more and more. So when there's no more, then we're going to fall apart.

Seventh- and ninth-grade students at the urban and rural sites had difficulty responding to our questions about science and technology—especially about technology. They seemed confused by what we meant by the words "science" and "technology." At times we had to ask for examples of what scientists do to help students understand the subject area before we could ask about the impact of technology or science on the way we live.

> **What do you think are some of the more important things in your everyday life that come from science?**

Rural, seventh

S_1: Science?

I: Yes.

S_1: School. Books.

S_2: Technology.

I: Technology in general?

S_2: Jobs.

I: What do you think?

S_3: Chemicals. Finding different chemicals.

S_1: Inventions.

We cannot assume that students below the eleventh grade understand what science and technology are or the difference between the two.

On all three grade levels, student conceptions of the breadth of the scientific and technological fields were extremely superficial. The technologies and technological issues/inventions metioned generally related to current issues being discussed by the media. Students were quick to cite the problem of spray cans, for example, but they lacked in-depth understanding of the problem.

Student Views of the Future

Differences emerged when the responses of urban students were compared to those of suburban and rural students.

Suburban and rural student predictions for the future seemed to grow out of their perceptions of the world today. For the most part, their forecasts were pessimistic: war and pollution were their primary concerns, with overpopulation following closely behind.

What predictions would you make for the world a hundred years from now?

War and Violence

Suburban, ninth

S1: I think there's going to be a major war that will affect the United States greatly and also the Soviet Union. For most of the great powers, it's going to create havoc all over the world. It's going to start a chain of developments that's going to cripple the world.

I: Do you see that happening really soon?

S1: In about ten years. . . .

Suburban, eleventh

S1: Either there is going to be a war or people are going to have to change systems a lot. Like there is probably going to be a big crisis. . . . I think the real nuclear crisis might not start between us and Russia. It is more likely to start, let's say, between smaller countries like India, like South Africa. What's going to happen if there is a revolution in South Africa and the South African government has an atomic bomb? It's touchy.

Pollution

Suburban, seventh

S1: Terrible. . . . Keel over and die.

S2: Everything will be polluted, and there'll be many more people lying about the streets and garbage.

Rural, seventh

S1: People would be wearing gas masks and that kind of stuff if it keeps going. . . .

S2: And if the pollution gets too bad, there might not be anything, hardly anything left.

Overpopulation

Rural, ninth

S1: Overpopulated. Won't have enough food.

Urban, seventh

S1: People [are] going to keep having babies and like someone [will] have a baby five more years from here and that baby will grow up and then they'll have kids so everybody'll live and where will they go?

Rural and urban students also mentioned rising prices and limited job opportunities as problems of importance to them. This is not surprising, since the sites from which they were drawn are located in areas currently plagued by high rates of unemployment.

While urban students expressed concern about violence and war in the world today, we found it particularly interesting that, in making predictions for the future, many of them reversed their position and expressed optimism. About 25 percent (primarily those from urban sites) regarded technology as having a positive and significant impact on the future. Students predicted exciting technological advancements and equated technology with "all that's good," using terms such as "electric windows and doors," "new products and ideas." Their visions included cities under water and revolving shopping centers.

A few students (5-6/90) responded in a religious framework when answering questions about current problems and the future.

> **What predictions would you make for the world a hundred years from now?**

Rural, eleventh

S1: The Bible says all kind of stuff.

S2: Yeah, and it's starting to come true, like earthquakes and stuff like that.... Just like, I don't know, well, what young people are doing. Well, in the Bible it said, you're not supposed to drink that. Meats you're not supposed to eat.... The way pollution is today, and ozone and all that stuff, they predicted it in the Bible and it is all happening. But people don't realize it, because a lot of people are losing faith in religion and they don't read the Bible, you know.

Urban, seventh

S1: There ain't going to be no world.

S2: It's going to be like they say in the year 2000—they are going to have rockets and everything. Backpacks on their backs so they can fly up in the air, and get gas and all that stuff.

S1: There ain't going to be no world.... It's going to end.

I: Why? What's going to cause it to end?

S1: God's going to come and do it. I don't know how to say it....

S_2: God hates violence. He said when the world starts coming to an end he's going to start showing it; and so he's showing it.

S_1: He's showing it's coming to an end. Everybody's dying.

S_3: Because people talk about their mother—they hate each other—killings. Those things are happening. He said it would, so it's coming to an end.

I: So you think those are the signs?

S_2: Ain't it going to come to an end?

S_1: Everything is. Everything it says in the Bible is true. Everything is.

S_2: If there wasn't no police, everybody would be dead because everybody would jump each other. When you go to the store you get mugged.*

Conceptual Understanding

Do students understand concepts such as system, dynamic behavior of systems, limits, cycle, and adjustment mechanism?

Do they understand the interrelationships among and within systems?

Do students view the past, present, and future within a systems perspective?

System

We attempted to learn what students thought constituted a life-support system. Plants, seed, soil, and food; water, oxygen, and fuel were the consistent responses we heard at all grade levels at each site. Less frequently, students (primarily rural) mentioned the need for some sort of rationing system. Several suburban students talked about the value of a governmental system. While urban and rural students simply listed elements, suburban students tended to explain the interdependencies among elements.

> **If we were to send a group of people to start a permanent colony with their own spaceship in**

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*While we are using this excerpt to illustrate how students approached our questions from a religious perspective, it is interesting to note the interweaving of this student's (S_2) comments about his view of today and his hopes for a technologically advanced future. This is an example of the contrast we referred to earlier between grim reality now and fantastic technological dreams for the future, a common theme in the responses of urban students.

space, and there was no possibility of their returning to earth or landing on another planet, what would that colony need in order to survive?

Suburban, ninth

S_1: I suppose one might create some sort of terrarium thing to be put inside where the spaceship was.

I: Why would you choose a terrarium?

S_1: Because it is a contained environment.

I: I see. Which means what?

S_1: It supports itself. It has everything it needs right in there. It has the air, it has the moisture, and it just sustains by itself.

I: I've never had a terrarium of my own. What would happen if you just let all the plants grow and keep growing?

S_1: I think of course that some plants would eventually die out. But if you had something of that sort, it would be best [to have] ... tended activity of some sort. You would have to have birth control. Population control.

I: Why would that be so?

S_1: Well ... you wouldn't have any resources to tap, to build another section.

Urban, eleventh

S_1: Food.

I: Okay, food. What else?

S_2: Water.

I: What would you need in order to survive?

S_2: Probably people.

I: What would you do to make sure that you didn't run out of food or oxygen, water?

S_1: There's nothing you could do, because you don't know how long you'd be up there. You'd be up there for too long.

I: You know that you're going to be up there forever. So what would you do?

S_2: I don't know.

S_1: Cry.

We were also interested in the human qualities most students would value in a "world" that had a very fragile and limited life-support system. We asked, "If you could choose people for this colony, what character traits would you look for? Would they be the same as those that are important in our world today?"

Besides being "patient," students said people would generally have to be friendly, cooperative, and intelligent, and that they would need to represent a number of professions, primarily the government, physical and biological sciences, and medicine. On the whole, students did not think that the qualities necessary for survival on their imaginary spaceship would differ from those important for survival on earth today.

It is interesting that in response to another question students mentioned greed as an important motivating force on earth (responsible for rising prices, for example). The qualities they seemed to value most for survival in a spaceship—cooperation and friendship—are antithetical to greed. Students did not appear aware of the inconsistency in their descriptions of real "present" behavior and hypothesized "future" behavior.

We were struck by the fact that, with perhaps one exception, no students perceived a need for knowledge of history, the social or behavioral sciences, education, or religion.

Interdependence

We were particularly interested in student understanding of the concept of interdependence among countries and regions. We chose to look at the factors involved in the production of food to see whether students understood this idea. We asked, "Where is food produced? Do all countries produce food? Could most countries be self-sufficient?"

Most countries, students told us, are not self-sufficient in their ability to produce enough food for their populations. Since food is produced by plants and animals, on land, in the sea, and in factories, students said that to be self-sufficient a nation would have to have adequate water supplies, a good climate, good soil and terrain, and adequate space. They also said a nation would need people with the appropriate skills to put such resources to work for them. Their answers, in other words, paralleled those they gave for the spaceship question.

Some students expressed a connection between births (mouths to feed) and the amount of food needed.

Every country produces some food. Do you think that most countries produce enough food to feed their own people?

Urban, seventh

S_1: No, like Russia don't.

S_2: The Chinese people make babies, a lot of people, a lot of room. Their babies are dying because of hunger, and people from Boston and all over the world are sending them food there for them to eat.

S_1: I know, like that program called CARE.

Suburban, eleventh

I: What would be necessary for a country to be self-sufficient in terms of producing food?

S_1: You'd have to have enough food to feed the population.

I: How would you go about that?

S_2: I think you have to assess how much food your country is able to produce. And then I guess you have to go through some form of birth control or something to insure that you don't go over this.

No students mentioned the relationship between the *type* of food consumed (for example, grain vs. meat) and the *number* of people who can be fed.

In responding to our questions, students tended to focus on physical requirements, to the almost total exclusion of social dimensions such as human values and behaviors. In terms of solving food crises, about the only solution students proposed was to purchase food from other nations.

Cycle

To get at another concept of interest to us, the *cycle* or cyclical process, we asked, "What is rain? What happens to rainwater after it falls on the ground?" We were interested to see if students would respond by describing a cyclical process.

Seventy-five percent of all the students interviewed were able to describe (and appeared to understand) the rain cycle. However, several urban and seventh-grade suburban students were unable to describe the rain cycle.

How would you describe rain?

Suburban, ninth

S_1: A cycle.

I: Can you describe the cycle?

S_1: It's around, evaporates, goes up in the clouds, gets heavy, falls down, sits around, evaporates.

Urban, eleventh

I: What is rain?

S_1: H_2O. It evaporates and forms into clouds.

S_2: And then it comes down again and evaporates.

I: Is that what happens to all the rain that falls on the ground?

S_1: No. It goes into ponds, streams. . . .

S_2: Drains, reservoirs.

Limits

We explored student understanding of the concept, *limit*: first to see what their understanding of the term was, and then to see if they understood the relationship between limits and problems they had mentioned as being of concern to them today—violence, overpopulation, and pollution.

Students seemed to understand short-term limits in the physical or natural world. But only a few students grasped the idea that resources have *finite* limits.

Is there anything on our earth that is limited?

Rural, seventh

S_1: Yeah.

I: Like what?

S_1: Like if you cut down all the trees, there'll be nothing left.

I: Anything else?

S_1: Fuel. If you used all that up you wouldn't have no more unless you got it from the sea like they say, or from another country.

I: Okay, what would happen if one of those things disappeared?

S_1: Trees. . .couldn't build houses. They'd have to be made out of steel, brick. No paper to write on. No pencils.

Suburban, ninth

S_1: You have to wait for some trees to fall over and get covered up and get into coal and probably that would be when man died out and something else will be in charge.

Students did not or could not always accept the implications of these limits for their own lives or for the future. For example, about one-third of the students interviewed found it difficult to accept the idea that limits actually exist and could result in the loss of life; they seemed to deny this possibility psychologically.

Suburban, eleventh

S_1: They can't solve shortages. Usually you don't totally run out. Unfortunately, what would happen is that people would get killed and enough people would start dying until there wasn't a shortage anymore. But shortages are a bad thing. But I don't actually see running out of anything.*

Others mentioned the possibility of finding a substitute for a depleted resource.

Suburban, seventh

I: You said the earth has everything you need. Are we ever going to run out of anything?

S_1: Eventually we will. You see, in about forty years if they don't find a source besides oil, we're not going to be here. We're going to be dead.

S_2: No, we won't [find a substitute]. We'll be all dead because I heard a scientist that my brother was talking to . . . telling him that we're using it at such a fast pace—even though we are trying to cut down we're still using it at such a fast pace—before you know it, it will be gone.

S_1: Did you ever hear about the ad that says, "What the sun uses in a single explosion is the most energy we've used in a lifetime?"

S_2: Every explosion that the sun has is two times the strength of a hydrogen bomb.

I: Solar energy, for example, is the solution to some of the problems?

S_1: I think it will work better.

S_2: What happens when the sun blows up in about five more years?

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*This is an interesting example of a biological adjustment mechanism. Student understanding of adjustment mechanisms is discussed later in this chapter.

S_1: People will be here for a couple more hundred of years.

About one-quarter of the students believed that resources, once used, could be recycled.

Suburban, seventh

I: What kinds of things are limited on earth?

S_1: I think water will be limited after a while.

S_2: Certain animals.

S_1: But animals can reproduce. That will happen.

S_2: The water will never be used up because the water is recycled. We drink it and dispose of it in our waste products and after that it goes into the sewage and to a new place where they filter it. Then it evaporates into the air and then it comes down as rain again. It fills the reservoirs. . . .

Only a few students talked about the concept of "limit" as a universal operating principle.

Suburban, ninth

S_1: Everything is limited to what it's at. . . . Everything. The tape recorders in this room are limited to two. That's how many there are. I suppose it only breaks down. We only have so many atoms or so many elements.

Rural, eleventh

S_1: Space. Food. We've had the same amount of water on this planet since we started. That's limited. And wildlife is limited. Our oxygen is limited. Everything is limited.

Commons Behavior and Adjustment Mechanisms

Garrett Hardin, in his classic essay, "The Tragedy of the Commons," (*Science*, 1968) described the problem of individuals confronted with a limited resource, the grazing land in a common. Each individual was free to receive all the benefits from adding another cow or goat, but the costs of the resulting overgrazing were distributed among all who grazed animals there. The result was the destruction of the grazing area—the "tragedy" of the commons. We gave students an example of "commons behavior" to see if they saw the immediate implications of the limits in that situation. We also asked students if they could suggest possible ways of dealing with the limits they mentioned, and if they could abstract from that situation to any other.

About fifteen families in a town decided that they would be able to make a lot of extra money in their spare time by raising goats and selling the milk and cheese. They did not have land of their own, but the town itself did own land suitable for grazing in the area. They proposed to the town manager that each family be allowed to bring two goats to the area to graze. Permission was granted, and in the first year everyone made a profit. The people talked about buying more goats the second year because the demand for cheese and milk was still greater than the supply. They anticipated an even more prosperous second year. What do you think would happen over time if the demand for milk and cheese continued to remain higher than the supply?

Students recognized some of the limits represented in this description; the most frequent reply from students at all grade levels and sites was that people would run out of grass. Less frequently they said that people would run out of space and/or that prices would go up.

To look at student ideas about how systems adapt and to see what adjustment mechanisms they considered, we asked how such problems as lack of space or depletion of the amount of grass might be solved. Students encountered some difficulty with this question. Most frequently they suggested limiting the number of goats. How the number might be limited was not suggested. They did *not* suggest individual, social, or political action. Their solutions were primarily technical improvements in land management.

Urban, ninth

I: Okay. Over a period of time, what would happen to the land?

S_1: It'd be destroyed. They'd eat the grass.

S_2: They'd eat the grass, and then there'd be no more grass to eat.

I: Can you think of any way that might be stopped or solved?

S_1: By cutting a piece of land up into four pieces so like they could eat in one area and when they finish up they could go over here.

Occasionally, some awareness of the market-and-price adjustment mechanism showed up.

Rural, ninth

I: Can you think of any way in which you might solve some of these problems that you thought of?

S_1: Let the grass grow.

S_2: Yeah.

S_1: And then let it grow a little more.

S_2: Have a few sections of land and then probably one year have the goats over on this land so that they can produce enough. . . . And then have another section of land so that . . . then they could switch over [the next year].

S_1: Well, if you put a higher price on it, people would be less apt to buy it.

Suburban students suggested almost no solutions, while seventh graders at the rural school and students in grades seven, nine, and eleven at the urban site did suggest the possibility of rotating the land and goats. A possible explanation for these differences is that rural students know about farming and urban students confront space limitations daily; but suburban students are not familiar with farming, nor do they face serious space limits.

When asked if they could generalize from the "goat situation" and provide us with similar examples with which they were familiar, about three-quarters of the students, from each site at all grade levels, gave somewhat similar examples. Overpopulation was suggested most often; less frequently, the unplanned use of natural resources was mentioned.

Suburban, seventh

S_1: That's probably how it's going to be on this planet in the future. We're not going to last until we have eighteen billion. Soon more people will die faster. There won't be enough room and then [the population will] go down and then up, up, up. Then people would die off.*

Suburban, ninth

I: Can you think of any examples of something like that that has ever happened or could happen?

S_1: Well, not right now, but in ten or twenty years people will be fighting for oil and everything. Food.

I: What will the world be like?

S_1: Like it will be, I don't know if this is true or not, it will not be like it is now. . . . It will be pretty much like the land is here except the population will be going up and there will be much famine.

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*This student recognizes a biological adjustment mechanism.

Other isolated examples related to the problem of population growth were given: the need for increasing amounts of food and the simultaneous increase of buildings, resulting in an environment of concrete and a lack of sufficient arable land.

Roughly one-quarter of all students across grades and sites were unable to think of any example analogous to the "goat situation" in the world as they know it. Students did not indicate in their examples a recognition of the basic notion of individual profit or benefit that leads to communal cost or loss.

Relationship Between Global Implications and Self

Having asked students for examples of limits and for their opinions regarding current and potential world problems, we wanted to know if they saw a relationship between the issues and limits they had cited and their own lives, particularly with reference to the future. To bring the discussion of current and potential world problems and the implications of limits closer to their personal experiences, we asked what possessions they thought they wanted when they were adults and on their own. Almost every student listed such things as a house, a car, a television, a stereo. Since all of these possessions draw on existing (and limited) sources of power and raw materials, we asked, "Do you think it will be possible for you to have everything you want?" What might possibly prevent you from having what you want?" All students gave similar answers: having what they wanted depended first on having a well-paid job, and second on "the economy." They viewed financial cost (their own ability to pay bills) as the limiting factor.

> **Do you think it will be possible to have everything [you have listed] when you grow up?**

Suburban, seventh

S_1: Depends.

[illegible]: Depends. You can't get a job unless you get a college education. And even though you're a woman, still you don't get a very good job because there's discrimination most of the time.

I: Just assume you did have a good job. Do you think you could get those things?

S_1: Oh, yes.

S_3: Right.

Urban, ninth

S_1: Well, I won't get everything that I want, that's one thing, you know, because of the prices. It takes a while to pay them off.

S_2: It probably isn't possible for everything, but if we really try we'll probably get most things.

I: What would stand in your way of getting what you want?

S_1: Well, money, for one thing.

S_2: Getting a job to get the money.

Rarely did students indicate that obtaining what they wanted would depend on the existence of the necessary energy or raw materials.

Suburban, seventh

I: Do you think that it's going to be possible to have everything you want?

S_1: No. You have to afford it before you can get it.

I: If you had the money, can you think of a reason you might not be able to get it?

S_2: They don't have any more.

I: Why wouldn't they have any more?

S_1: Maybe the company cost too much.

I: What could make it more expensive?

S_1: The electricity.

I: What makes the electricity more expensive?

S_2: People are wasting electricity so they have to have just a minimum of electricity.

I: One of you said records and stuff. I was wondering if you think that if every one of you wanted a stereo, you would all be able to have one. Can you think of anything that might possibly keep you from getting one?

S_3: Yes. The shortage of oil.

Students generally did not link their predictions for the world to their own projected life experiences. Even though many predicted war, few students suggested how such a war would affect their ability to have what they wanted.

Following is an interesting example of how one student saw the interaction of technical, political, social, and market adjustment mechanisms.

Suburban, eleventh

I: Do you think we're running out of anything?

S$_1$: [The idea that] we're running out of energy I think is a lot of bull.

I: You do?

S$_1$: We're running out of fuel but oil has only been around for 100 years. Or 150 years. If we could get it off the ground I think solar energy would be a great idea. I think [its price] might be low. I think they are afraid of it because no one can control it like oil. I think that is why people don't want to develop it, because [if] you have solar energy nobody can really control the market on it, like oil.

We wanted to identify student understanding of factors in the market-and-price adjustment mechanism. Did they see rising prices as the by-product of the interaction of the human and natural systems? Most students attributed rising costs to purely human factors, primarily greed.*

Suburban, seventh

I: Why do prices keep rising?

S$_1$: Because somebody wants more money.

S$_2$: He's greedy.

Rural, ninth

S$_1$: People want more money. They are more selfish, probably.

I: Can you think of any other reasons? For instance, what makes a farmer's costs higher?

S$_2$: . . . the prices go up on their grains and stuff.

S$_1$: I think it's like a chain reaction, probably. One person puts their price up and the next person has to buy that, so he has to put his price up on cattle or something like that. I mean, it goes on.

Suburban, eleventh

S$_1$: Because materials are getting scarcer and because people don't want to work as much. Farmers are getting sick of not being paid enough for their work. Their work is hard labor and they don't feel that they are being treated fairly.

I: How come farmers' costs are going up?

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* It is possible that student responses were influenced by the rise in prices at the time of the oil embargo of 1973, a rise that was represented by the mass media as primarily due to the actions of oil-producing nations and of big oil companies that came out ahead; such an attitude is now pervasive in their thinking.

S_1: It's getting more difficult to produce. They have to pay for their machinery and things like that. It is all a big cycle. Then you go to the factories and the employees want more money for their time to build this machinery and then the company head says if our employees want more money then we are going to have to raise the prices and it goes back to the farmer.*

I: What do you think is causing the prices to go up?

S_1: Greed. The desire to want things.

Only about 15 percent of the students attributed rising costs to diminishing supplies (although their explanations of the connections between diminishing supplies and increasing costs were not always entirely clear). These students were primarily, but not exclusively, from suburban and rural areas.

I: Why do you think prices keep going up?

Rural, ninth

S_1: Supply and demand does have something to do with it. Like when there's a certain amount of supply, it goes up, and when there's an overabundance and nobody's buying them, the price will go down.

Suburban, ninth

S_1: Prices keep rising so people can make ends meet, but really it's all a circle. Prices go up, raises go up. When raises go up people feel the prices have to go up to get the money.

S_2: That's not exactly it. It's not exactly a circle. Maybe there's a bad crop one year and they have to charge more for it to maintain a balance.

S_1: Prices are going up also because certain things are more in demand than they were say fifty years ago. The population just in the United States is much bigger than it was fifty years ago so there's more demand. It's less for [more] when we have a greater population.

Students were generally skeptical about the argument that the depletion of energy sources was contributing to rising costs. Their responses at times showed a reluctance even to recognize that resources exist in limited supplies. (See footnote, page 51.)

I: Why do prices keep going up?

Suburban, seventh

S_1: I think the oil companies don't want anybody to get the money.

***This is a rather sophisticated and rare description of the interactions among costs and prices in the market-and-price adjustment system.**

They don't want anybody holding it back when the prices go up. Now it's a gas war. My mother was riding down some streets and you could see "Gas Sale," "Gas Sale." Now the prices are going down.

I: She is saying that things are running out or are harder to find. . . .

S1: Sure there's a shortage, but there is always a shortage. Even if you have everything you need, you still would like more. . . . There is no person, I don't think, that is completely satisfied with himself. . . . It is a gas war. They've all got the gas. They don't know what to do with it. They have so much that they are trying to get rid of it some way, and they are trying to get rid of it as fast as they can.

Suburban, ninth

S1: It's political. The Arabs. And the oil to be produced is all involved in a cycle. It costs money to trade oil and to search for oil and people have a strong customary tradition to balance out the cost of finding the oil and charging the balance.

I: Do you accept the arguments that things like oil are running out and that—

S1: I don't accept the fact that it's running out at this time. But I do believe and will accept that oil will eventually run out. But at this time, no.

Dynamic Equilibrium

We have already noted a few examples of students describing adjustment mechanisms that deal with the interrelationship of social and biological systems. One of our questions focused specifically on student understanding of the ways systems balance and adapt to changes.

> **The purpose of a thermostat is to keep a room at a particular temperature. It turns the heat on when the room temperature goes down, and turns it off when the room temperature returns to the desired level. Can you think of anything else that works this way to keep something the same?**

The examples students cited most frequently were, first, the body's adjustment to different temperatures and conditions, and, second, the effect of seasonal changes on the earth. Political, social, and biological examples were also given: our governmental system of checks and balances; the balance of nature (natural selection); the way in which plants at night replace oxygen used up during the day; and incubators, air conditioners, and humidifiers. Not all of the examples were technically accurate. We felt that students grasped the general idea but, for lack of detailed special knowledge, were not totally correct in their responses.

Suburban students gave a few more examples of adjustment mechanisms than rural students did, and rural slightly more than urban. It seems fair to say, however, that all groups generally understood at least one way in which systems adapt. Differences across grade levels were negligible.

Methodology

What competencies do students already have for thinking about problems of systems, ecology, and growth? For example, do they already have skills in the areas of problem identification, data gathering, analysis, design, and evaluation that we might build upon?

Problem Identification, Analysis, and Evaluation

When we probed students' problem-solving abilities in the areas of growth and ecology-related issues, students suggested that "looking around" was the method they tended to use to see if something was problematic.

> **When people tell you about problems we might have in the future, how do you sort out their opinions for yourself? (How do you decide whether something is in fact a problem?)**

Suburban, ninth

S1: By realizing the reality of what they're saying. If you notice that scientists say the sky is being poisoned ... just the other day I was walking in the city and I was kind of choking. I realized that something must be done.

Rural, ninth

S1: You can live there.

S2: You can just look at the water and the streets.

I: You mean ... to see if it is polluted?

S$_2$: Just take a look.

I: Is there any other way you can test it, do you think?

S$_2$: No.

Rural, eleventh

S$_1$: I'd take a look and see.... If you look, you can see.

Suburban, seventh

S$_1$: You could have voting. You could have a questionnaire to see if everybody thought that was a problem....

I: Is there any other way you could find out?

S$_1$: It's all in the point of view.

S$_2$: It's really a very abstract way of thinking. If you have a problem and everybody agrees it is a problem, you still don't know if it is a problem.

I: What do you do about it then? What if you were the head of a government committee and everybody came to you and said, "We need twenty million dollars because of this problem"? How would you decide whether it was worth putting money into it or not?

S$_2$: If it is a desperate human situation.

I: Then you'd have to wait until it became desperate?

S$_2$: No. Preventive measures.

S$_1$: Like a lot of things are decided upon. A very unreliable way.

It seems fair to conclude that students generally did not know how to identify issues that might become problems in the future, nor did they know how to evaluate or assess problems identified as current concerns by the mass media (for example, pollution and overpopulation). They tended to rely rather tenuously on the opinions of others and on their own experience immediately after the problem had been identified as a crisis.

Students were also asked how they would solve the problems they had identified. Their suggestions varied. The only solution that was suggested by more than five students was the use of laws reinforced by severe punishment. Other ideas suggested by one or two groups of students or by individuals included: "use solar energy," "use electric cars," "stop giving aid to other countries until their population deceases," "plant trees," "control population (growth)," "recycle things," "take only what you need," and so on. At least five suburban students said population growth cannot be controlled.

Do you think that scientists and engineers will be able to solve the problems we are having with the earth's energy and resources?

Most students (70 percent) said that scientists would *not* be able to solve all the earth's problems. They said such things as: "You can't stop people from killing one another." "Everything has its limits—there'll never be enough." "You can't force people to practice birth control." "People won't obey laws." Some students suggested that scientists were working against the clock. While the number of students giving any one reason was small, it is interesting to note that *students viewed the problem as stemming from limitations in individual human behavior*—not from limitations in technology or from ineffective political, legal, or economic processes.

Control

Students seemed to feel they had relatively little control over much that takes place around them.

Most students agreed that the most control they had was control over themselves and their possessions.

What kinds of things do we have control over?

Suburban, seventh

S1: I have real control over ... everything I do, really. No one can make me do anything. No one really can make you. Even if they threaten to kill you, they can kill you. No one can make you, absolutely make you.

Rural, seventh

S1: The volume on the television.

I: Okay. What else? Can you think of anything else that you control?...

S2: My bicycle.

I: Can you think of anything?

S1: Clothes.

I: Anything else?

S2: Pencil, ... games, TV, car... .

Urban, ninth

S1: What we do, what we want to do.

S2: How much food we eat, probably, or something like that. Or how much gas we use up.

I: Can you think of anything else that you control?

S1: You don't control much except ourselves.

For older students, the idea that control extended beyond themselves seemed related to attaining adult status—becoming eighteen, being able to vote, having their own businesses, marrying, and so on.

Suburban, eleventh

S1: At this point, I don't even really have control over myself. You don't have control over yourself until you're eighteen and then you're granted independence.

I: Okay. So when you're eighteen and older, what do you think you'd have control over?

S1: You'd have control over whatever you want to do. You have control over yourself. That's about it.

Suburban, ninth

S1: I have or will have partial control of the government of the United States when I reach the age of eighteen. There is probably a lot more power for the individual than people think. Government and socially. The pacesetters of society.

Grade and Site Differences

Do students differ in their approaches to thinking about problems of systems, ecology, and growth as a result of grade level and/or urban/rural/suburban differences?

Grade

We did find some differences between the responses of seventh graders and other students in a number of areas. Seventh graders lacked the vocabulary of the older students; generally, seventh and also ninth graders did not know what we meant by the term "technology," nor did they use the word "cycle."

Students at all levels saw the basic principles underlying cycles and adjustment mechanisms. Older students had a small advantage over the younger ones in this conceptual field. Older students also expressed a greater sense of control: they expected to assume somewhat greater control over their environment once they gained the privilege of casting their votes and started careers.

In terms of whether students understood and could illustrate particular concepts, differences based on grade became minimal with this student sample. At all grade levels there exists some understanding of some concepts and at all grade levels there is a lack of understanding of other concepts (such as entropy) and a lack of skills (such as those related to problem solving). This general distribution has contributed to a lack of differential responses to our questions about some concepts, but suggests as well that potential understanding and ability exist at all grade levels in the sample.*

Site Differences

Site differences emerged more clearly. Suburban and rural students were far more pessimistic than urban students about the future. Urban and rural students expressed more concern over violence in the present than did suburban students. Students everywhere put the blame for rising prices on human "greed." Urban students were most consistent in this respect, providing almost no other reason for inflated prices.

Suburban students were more verbal than students from other sites. At times it was difficult to know whether suburban students actually knew more or simply expressed themselves more readily; we consistently came out with more information on them and less on the others. Whatever the reason, suburban students tended to explain the interrelationships among elements they were discussing more often than did students at the other sites, particularly with reference to the spaceship question. They may actually have a better grasp of "system" as a concept. If so, the possible explanations for this difference are many: differences in ability, differences in school programs, and/or prior exposure to similar ideas.

The challenge presented by our results is to help students move beyond the ideas and attitudes so eloquently expressed by a seventh-grade suburban student:

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*A study entitled "An Analysis of Strategies for Teaching Environmental Concepts and Values Clarification in Kindergarten," conducted in 1976 by Harold R. Ungerford at Southern Illinois University and Covey K. Bryant of the Carbondale (Illinois) schools, indicates that environmental education can result in some meaningful learning outcomes on the part of five-year-olds.

Nobody is immortal. We're all going to die some day. But if you are going to die you might as well be happy while you're on earth. And if you sit around worrying about the atom bombs and the energy crisis and everything, you're never really going to have a good life. You get very depressed.

Summary of Formative Evaluation Findings

Student World Views

The Present

When asked what they thought of the earth as a place to live today, students generally said it was "good" but many problems plague it: violence and war, pollution, and overpopulation.

The Future

Students' predictions for the future are predominantly grim, with violence, pollution, and overpopulation remaining primary concerns. Interestingly, urban students are concerned with violence when talking about the present, but are more positive than suburban and rural students in their forecasts for the future. They expect science and technology to have a powerful and exciting impact on the world of the future.

Students in general do *not* make direct, personal links between their predictions for the future and the implications of those predictions for their own lives.

Impact of Science and Technology

Students' views of technology and science tend to reflect popularized notions of these fields. They enumerate examples of current technological and scientific interest that are popularized by the mass media, such as the possible effect of spray can ingredients on the ozone layers. But as far as we can see, they do not understand how such problems are identified, studied, or evaluated. They do not appear to integrate natural and social science data, and tend to assign responsibility for solving environmental and growth problems solely to the scientific community. They appear ready to accept scientific findings largely without question.

Students view the effects of science and technology as both positive and negative. They understand that contributions intended to have positive effects can have unforeseen and often negative, delayed effects.

Younger students (seventh and ninth graders) appear to understand these fields least. They are unclear what is meant by "technology" or how the work of scientists and technologists affects their lives, except in the most simplistic way: as "inventions" and "chemicals."

Conceptual Understanding

Systems

Suburban students seem to have an edge on rural and urban students in having a "systems perspective." Rural and urban students tend to list various elements within a system, but do not describe the interrelationships of those elements.

Interdependence

When talking about a system, students rarely give equal attention to technical and social factors. They emphasize the technical aspects of the problem rather than personal-social dimensions, except perhaps in the case of inflationary price increases where the reverse is true.

Cycle and Adjustment Mechanisms

Students at all levels appear to understand several types of physical cycle and adjustment mechanisms—for example, biological adjustment mechanisms.

Limits

Students tend to associate limits with the physical or natural world; they do not appear to understand that limits operate universally, nor that limits affect all individuals, including themselves. Some students reject the idea that limits exist; others feel that substitutes will be found for depleted natural resources. They do not appear to understand the principle of entropy.

Students do not attribute rising costs to the existence of natural limitations and the consequent depletion of natural resources, but to human factors—primarily greed and, secondarily, political manipulation. They cite ability to pay as the major hurdle to overcome in providing for their own needs.

Methodology

Problem Identification, Analysis, and Evaluation

Students generally do not know how to identify problems such as overpopulation, nor do they have skills to evaluate the extent or implications of such problems. Because they don't have these skills, they tend to rely on the opinions of others, and to do so, significantly, *after* problems reach crisis proportions. (Students, of course, are not alone in this respect.)

Advocacy

In general students felt their area of control was limited to themselves and their tangible possessions. Older students expressed their eagerness to engage in adult activities such as voting and working—activities they feel will increase their control over themselves and also allow them to assert their influence on the world around them.

Grade and Site Differences

Urban students were far more optimistic about the future and more concerned at present about violence than rural or suburban students. With respect to the future, suburban and rural students appear to be more concerned about environmental problems and population-growth issues. Suburban students seem more frequently to integrate understanding of the ethosphere and biosphere than do students from other areas.

Grade differences appear to be minimal. Seventh graders lack the vocabulary of older students, but appear to use the same concepts, to share roughly the same skills, and to share the same attitudes as the older students.

Although we interviewed an equal number of boys and girls, sex differences were not studied for purposes of this report.

Review of Curriculum Materials

Three questions framed our review of curricula:

- What are the strengths of existing materials?
- What are the shortcomings?
- What elements, currently missing, would help students to develop better skills, knowledge, and attitudes for future global survival?

Selection of Curricula

We began with a broad definition of the types of material to be considered for review.

Grade Levels:	1–12 (with an emphasis on secondary school)
Student Materials:	Texts, courses, programs, readers, simulations, games, films, and filmstrips, from • commercial publishers • nonprofit organizations (for example, Audubon Society, Hudson Institute, World Future Society) • government agencies • state and local departments of education • professional associations (for example, National Association of Science Teachers, Massachusetts Teachers Association) • teachers' experimental materials, often mimeographed, developed for their own classes
Teacher/Educator Materials:	Guides accompanying student texts and courses identified above; suggested course outlines; instructions to teachers for student activities and projects in professional periodicals and publications (*Science Digest, Intercom, Social*

Education, The Futurist); relevant educational and/or trade books (for example, Mark Terry's *Teaching for Survival*).

Subject Areas: Biology, botany, chemistry, civics, current problems, ecology, English (literature and language arts), environmental studies, future studies, general/natural science, geography, geology, global studies, government, history, social studies, technology, world problems/world development.

Teaching Time: One class to one full year or more.

This broad definition insured review of a vast range of materials that students might encounter in grades 1–12.* But the definition also presented a dilemma. From the hundreds of course offerings, how could we identify those that seemed most likely to develop a comprehensive approach to issues of growth and the earth's future?

To select materials directly relevant to these concerns, we solicited suggestions and recommendations from knowledgeable scholars, teachers, professionals, and organizations. We also contacted individuals and groups who held a variety of perspectives, including conflicting viewpoints.

As a first step, EDC convened the Planning Conference of October 3, 1975. Scholars and teacher consultants were asked to identify the important areas of concern for education about growth and survival and to recommend materials to be reviewed. Simultaneously, 31 major educational publishers (see Appendix) were contacted and asked to recommend curricula that "taught about the environment and how people have used it and/or can use it in the future"; and "courses that teach about how systems work." Bibliographic resources and pertinent summary reports (Perelman and Bergquist's *Growth and Education;*; ERIC; *AAAS Book List*; Population Index) were consulted. Professional organizations and research groups (Hudson Institute, Commission on the Year 2000 of the American Academy of Arts and Sciences, Massachusetts Marine Educators) were also contacted for recommendations.

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* Initially, our researchers examined several experimental college-level and graduate-level courses dealing with growth-and-survival concerns. Since the reading level and conceptual structure of these materials were extremely sophisticated, we concluded that they would not be used widely in high school settings; therefore, we did not include them in our analysis.

We visited resource centers and libraries such as the Hatheway Environmental Education Institute in Lincoln, Massachusetts, which has the most extensive collection of environmental education materials in New England. Mrs. Louise Maglione, librarian at Hatheway, kindly spent many hours helping us to identify curricula that teachers and visitors to the center had found useful in their classrooms.

Via telephone or on-site visits, EDC researchers interviewed knowledgeable professionals to obtain their recommendations and evaluations. (For a complete listing of those interviewed, see Appendix.) We visited teachers in the New England region who had developed outstanding programs, either by synthesizing existing curricula or by developing completely new courses of study, and we talked with teachers in other parts of the United States who had developed similar programs. These contacts led not only to specific recommendations of commercially published materials, but also to an extensive miscellany of course outlines, resource papers, suggestions for student activities, and unpublished manuscripts for review.

During the fall and winter of 1975-76, EDC staff attended several national and regional conferences: Limits to Growth Conference, Houston, Texas; National Council for the Social Studies Convention, Atlanta, Georgia; Zero Population Growth Conference, Boston Museum of Science. At these conferences we met and obtained advice and perspectives from many professionals.

Based on recommendations from scholars, teachers, and professionals, and after an initial review by our researchers to determine whether suggested materials were in fact related to the area of growth implications and the earth's future, 143 curricula (see Appendix) were selected for in-depth analysis. Although these are but a sampling of the resources available, we believe they represent some of the most promising materials that now exist for helping students understand growth-and-survival issues.*

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*It was impossible, given limitations of staff time and money, to determine how widely the materials reviewed are used. The only way to do this, since the information is not available from publishers, is to contact the more than 50,000 private and public schools systems across the nation. This task was beyond the scope of this study. However, from informal conversations with publishers, administrators, teachers, and other professionals, we estimate that roughly 25–40 percent of U.S. students in grades 7–12 are exposed to materials similar to those in our sample.

The Sample

The 143 items selected for review range from individual pieces, such as a film or game designed as a separate entity, to unit outlines, year-long courses, and course series spanning several years. The tables below indicate the range of levels, teaching times, and classroom settings of the materials in our sample.

No. of Items	Percentage	Grade Level
6	4	1–3 (primary)
4	3	1–6 (elementary)
17	12	4–8 (elementary/middle)
9	6	1–12 (elementary/middle/senior high)
11	8	6–8 (middle)
16	11	6–adult (middle/senior high/adult)
50	35	9–12 (high school)
23	16	Teacher/adult
7	5	Other
143	100	

		Teaching Time
13	9	One day
33	23	One week
6	4	One week to one month
12	9	One–two–three months (semester)
16	11	Semester/year
4	3	Several years
59	41	Other (Materials that fell into this category offered a range of activities from one day to a year, depending on teacher selection. They do not fit into any of the above categories.)
143	100	

No. of Items	Percentage	Classroom Settings
33	23	General Science
26	18	Social Studies
17	12	Biology
12	9	History
11	8	Current Problems/Civics
44	30	Other (Supplementary readers, Humanities, Language Arts, Literature; materials for conferences, community leaders, 4-H groups, teacher workshops)
143	100	

Criteria for Review

Criteria were based on the learning goals listed on page 9 of this report. The learning goals and criteria for curricula review were corroborated independently by the Belgrade Conference on Environmental Education (October 1975), where representatives from sixty-five nations unanimously called for all governments to teach their citizens about the planet's vulnerability and its conservation requirements. Belgrade conference participants expressed the need to "consider the environment in its totality . . . ecological, political, economic, technological, social, cultural, and aesthetic." Consistent with their guidelines, we have sought to find the extent to which existing programs:

- provide a multidisciplinary approach
- emphasize active participation in preventing and solving environmental problems
- examine major environmental issues from a world point of view while paying due regard to regional differences
- focus on both current and future environmental situations
- look at all development and growth from an environmental perspective
- promote the value of involvement and cooperation at local, national, and international levels

—UNESCO-UNEP Environmental Education
Workshop,
Belgrade, October 1975*

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*These recommendations are currently being reviewed by UNESCO member nations prior to final publication in the fall of 1977.

Further corroboration of our criteria came from the U.S. Office of Education's Environmental Education Act, and from *Growth and Education* (December 1974), the final report of a project that sought to assess existing resources for teaching and learning about growth problems on the postsecondary level. The Environmental Education Act* states that the "environmental education process is multifaceted, multidisciplinary, and issues- or problem-oriented."

The authors of *Growth and Education,* Perelman and Bergquist, concluded:**

> A number of educational programs now in existence attempt to do part of what we believe is needed for an adequate ecological education; e.g., programs in environmental studies, urban studies, future studies, systems science, System Dynamics, etc. However, we have discovered no programs which do all that is probably necessary.

The authors define six characteristics they believe are "essential to an adequate educational response to our current state of ecological crisis":

> Multilevel
>
> It must focus on all three levels of learning. [1) habitual and conditioned; 2) learning to learn and acquiring character traits; and 3) expansion of consciousness and capacity for paradigm change.]
>
> Interdisciplinary
>
> It must span the boundaries [among] conventional disciplinary and professional fields.
>
> Problem-centered
>
> It must focus on and be responsive to the critical problems of the real world.
>
> Future-oriented
>
> It must be forward-looking and concerned with the imagina-

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*Public Law 91-516: 20 U.S.C. 1531-1536. *Federal Register,* Col. 39, No.99—Tuesday, May 21, 1974.

**Perelman and Bergquist, *Growth and Education: A Strategic Report to the Rockefeller Brothers Fund on the Implications of Growth Policy for Postsecondary Education.* Boulder, Colo.: Western Interstate Commission for Higher Education, 1974, pp. 21-23.

tion, design, and realization of alternative, sustainable futures.

Global

Its perspective must be at least planetary.

Humanistic

It must be concerned with the maximum realization, exploration, and expansion of . . . human potential.

Procedure

To help us assess the extent to which existing course materials incorporate these criteria, we developed a Review Form (see Appendix). The form contains closed and open-ended questions, and enabled us to record and organize data on the great variety of materials in our sample. We noted which curricula emphasized concepts we identified as critical (pp. 12–29), which aimed to develop problem-solving skills, and which dealt with the values and attitudes inherent in the materials. We assessed learning strategies and the extent and nature of teacher support. We tried to assess such qualities as future orientation and to identify the intended audience. We sought to identify existing strengths that might be built upon, used, or adapted in developing new programs on growth implications and global survival.

Summary of Findings

A summary of our findings is presented topically, using as a framework nine research questions that guided our investigations:

- What scope of study do courses presently offer for teaching about growth implications and the earth's future?
- What emphasis do existing curricula give to teaching key concepts identified for this study?
- How comprehensively do existing curricula teach about food, population, and energy?
- Do materials attempt to teach problem-solving skills applied to growth and survival concerns?
- What values and attitudes do materials present?

- How do materials handle potentially upsetting issues?
- How comprehensive are individual programs in providing multiple modes of learning?
- How comprehensive are individual programs in terms of giving teachers sufficient support to enable them to reach course goals?
- To whom are existing materials addressed?

For each question, we identify the criteria used to review the materials and then describe what we found in the sample.* These results represent our best reading of a potpourri of materials, ranging from elaborate six-year programs to minicourse outlines, to instructions for using a single activity, game, or film.

What Scope of Study Do Courses Presently Offer for Teaching about Growth Implications and the Earth's Future?

What We Looked For

We believe programs and materials on growth implications and the earth's future should:

- have an interdisciplinary approach, and emphasize the interrelationships of people and nature
- be local, national, and global in perspective
- help students understand past and present experiences and issues, and also help them become aware of, and able to plan for, alternative futures**

What We Found

As a whole, the materials reflect the scope of our concerns. But we found no single curriculum that attempted to combine knowledge about the biosphere and ethosphere with personal involvement and problem-solving skills. Materials tend to focus on a single issue

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*It should be emphasized that by citing weaknesses in any curriculum reviewed we do not mean to condemn the curriculum as worthless. Similarly, by citing the strengths we found, we do not imply that a program totally fulfills the identified criteria.

**This belief is based on our own experience as curriculum developers and on conversations with scholars and practitioners, as described on pages 8–9 of this report.

(conservation; population growth; technological, political, or economic developments) or on selected concepts from one discipline ("food webs," biology; "exponential growth," geography and demography; "pollution," ecology).

Interdisciplinary Perspective

Only 16 percent of the curricula reviewed (n = 143) have a multidisciplinary focus. Many of this group are cross-disciplinary (using one perspective on one issue or question) rather than interdisciplinary (using several perspectives to look at the same issue). For example, Risteen's *Investigating Man's World* (an elementary social studies series that attempts to integrate perspectives from geography, anthropology, economics, history, political science, and sociology) presents data from each discipline sequentially. In investigating Canada, students learned how various specialists (each studying a different issue) have "worked to solve Canada's problems." But students do not see how a problem might be studied by people from two or more disciplines. In studying land use, for example, it would be helpful to have several perspectives on the effects a technological intervention such as a new highway system might have on both the land and the people. How did construction of the new highway affect the economic base of the community? Did it provide people in the area with more and better paying jobs? Did the new system change residential or recreation patterns? Since about two-and-one-half acres of land off site are disturbed for every one mile of divided highway constructed, how did the new system affect local flora and fauna? It is only by integrating perspectives from several disciplines that students can begin to see the range of effects a technological intervention can have.

Data and concepts—especially those from the physical sciences—are often inaccurate. For example, *Eggs,* a film about population growth, implies that an acquired trait (piano playing) can be directly inherited by the next generation. According to the biological theory of natural selection, characteristics acquired during a person's lifetime (piano playing, college education) cannot be passed on genetically to offspring.

The problem of inaccuracies may be attributable in part to the fact that most materials (approximately 75 percent) were developed by only one or two authors. Developing effective and accurate multidisciplinary materials would seem to require the combined efforts of scholars and practitioners from each of the disciplines represented, to avoid transmitting misconceptions.

Many teachers commented on the difficulties they have using multidisciplinary materials. As one teacher said:

> The main problem is that we don't have the training. . . . I'm a chemistry teacher. I need some special training to deal with social studies issues. I don't have the techniques to teach via role plays, debates, or to know how to deal with open-ended questions and concepts. It's quite a difference from teaching laboratory procedures!

Approximately 60 percent of the sample provide no teacher guides or background data. When guides are provided, they tend to be skimpy. They presuppose an understanding of concepts and methodology.

In our sample, one of the most interesting interdisciplinary curricula is an elementary series, O'Donnell's *The Social Sciences: Concepts and Values*. Offering a variety of resources—student books, teacher guides, activities booklets, sound filmstrips, study prints, and sample tests—the course uses data and concepts from many areas of the social sciences to explore human behavior. However, course materials rarely draw upon data from the physical sciences to examine the interrelationships between people and nature. For example, although steel production is discussed in detail, the scientific concepts needed to understand the problems of energy use or pollution often associated with its manufacture are not presented.

Despite attempts to integrate several disciplines, traditional departmentalized frameworks* tend to shape the content of most materials: biology texts focus on the identification of plants and animals; social studies materials examine political and social trends over time. Generally, biology texts do not discuss the role of technology, explore values, or examine alternative solutions to such problems as energy exploration and utilization. Similarly, social studies courses may discuss the economic effects of pollution on a community, or the conflicting values involved in an issue, but they rarely present the concepts needed to understand the physical basis underlying pollution problems or proposed controls.

Local/National/Global Perspective

The majority of materials focus *either* on students' immediate surroundings (local land use, pollution, exploration of nature sites) *or* on specific global concerns (the capacity of the earth to support continued population growth). Regional issues, unfortunately, are usually omitted.

Creating materials that are both immediate and specific enough to be meaningful to students and broad enough to encompass a global perspective is difficult. Yet putting these perspectives together—considering personal and global claims simultaneously—is the very task that people find hardest to do. A beginning effort has been made by the Management Institute for National Development. Their course outline, entitled "Global Development Studies," takes an historical view of the "global community of societies." The outline suggests that students spend half the year tracing the history of the growth of global interdependence and the second half analyzing case studies of problems, such as the depression of the thirties, from local, national, and global perspectives. The outline, however, does not include an ecological or personal perspective.

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*This probably reflects the practice of most American secondary schools of separating academic disciplines. Publishers do not commission interdisciplinary materials because they tend to sell less well than traditional, narrowly focused texts.

"Baldicer," a game about resource allocation developed by Georgeann Wilcoxson, represents another way of introducing students to a consideration of both global concerns and regional implications. It seems likely to foster a sense of the need for global cooperation in order to survive, and the need to consider the interests of both industrialized and nonindustrialized nations.

"Project Quest," a year-long course developed by Brockton, Massachusetts teachers, is another beginning attempt to integrate local/national/global perspectives. One teacher described the course's origins by saying:

> We decided to try to attack the interaction points between large and small scale because we found that students' focuses were out of whack. . . . The kids here could not name the river systems around them but they could name the river systems of Egypt [the Nile] and South America [the Amazon]. . . . We felt kids needed to see how things are related to each other and they need to feel that they can make an input into decisions affecting them. The vehicle we chose to begin with was to look at the hydrological system in Brockton first. . . . This would serve as a model for how all systems work. After all, the same principles apply to traffic patterns as well. And in almost every case, you can tie your local community into world and national events. Kids need to perceive problems in a more articulate way—not in the global Walter Cronkite sense first. . . . Then we go on to examine regional, national, and global perspectives. But starting this way . . . gives students a sense of confidence . . . a sense of optimism. . . .

Past, Present, and Future Perspective

Only three of the items in our sample attempt to integrate a broad time perspective; however, no curricula succeeds. One group of materials—future studies courses—do address the future in any depth. Only this group tends to move beyond "gloom and doom" warnings about possible future trends (overpopulation, resource depletion) to encourage the active planning of alternatives based on past and present data and experience.

One example is a two-semester course developed at Port Huron Northern High School, Michigan, in which students plan for the future of their own community. The first semester is devoted to familiarizing students with such concepts as land-use planning. During the second semester, students do extensive community field work and apply these concepts to current issues (construction of shopping malls, highway systems) in their area.

Another program that integrates a broad time perspective was developed by local teachers in cooperation with the Future Studies Department, Minnesota Science Museum. (This group has been instrumental in introducing future studies throughout the Middle West and West through a series of teacher workshops.) One Minnesota student who participated in the program commented:

> Before I participated in futuristics, I suffered a type of doomsday syndrome. I saw myself as being insignificant in the making of the future, like it was some kind of immovable tidal wave, so I never really gave it much thought.

Too often, materials that do a good job of orienting students toward the future sacrifice the student's need to understand the past and present. Many future materials (such as Hunt and Miller's *Advent: Future Studies and Research Curriculum Guide, Learning Resources Guide,* and *Hopes and Fears Switchboard*) focus productively on future methodologies: forecasting techniques, Delphi, scenario writing, cross-impact matrixes. However, scant attention is paid to the ways in which an understanding of the past can empower students today. For example, by focusing on situations where real people have had to make tough choices, students can be encouraged to feel empowered about their own choices. As one teacher said:

> If students view history as inevitable, they will tend to view the future as inevitable too. We are just sitting here watching it unfold; it is not participatory; we don't get into the act. We must give students the notion that we *do* decide important things in our lives!

What Emphasis Do Existing Curricula Give to Teaching Key Concepts Identifed for This Study?

What We Looked For

In assessing materials, we looked for each concept* identified by our scholars and consultants. Also, we checked whether the materials dealt with the interconnections of systems—the idea that you can never tinker with one system without affecting others.

What We Found

The following table, in rank order, shows the percentage of courses stressing the concepts we feel are important for growth-and-survival curricula. Thirteen percent of the curricula sampled present *none* of our key concepts.

Courses Stressing Key Concepts

No. of Items	Percentage	
85	60	Adjustment mechanisms (total)
20	14	Social
19	13	Biological
19	13	Technological
17	12	Market
12	8	Political
60	42	Biosphere systems
33	23	Ethosphere systems
33	23	Limits
21	15	Dynamic behavior of systems
20	14	Delayed effect (in time)
19	13	Exponential growth
19	13	Intervention points
19	13	Trade-offs
17	12	Displaced effect (in space)
10	7	Sources and sinks

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*See pp. 12–29 for a discussion and definition of key concepts identified for this study.

7	5	Moving or dynamic equilibrium
6	4	Commons behavior
4	3	Paradigms
4	3	Entropy
4	3	Disaggregation and provisional boundaries
3	2	Integration of past, present, and future

Sixty percent of the sample include the notion of *adjustment mechanisms*. However, most materials focus on only one type of mechanism and usually link the discussion to a specific issue. For example:

- *biological* adjustment mechanism (ecosystem)
- *social* adjustment mechanism (population growth—need for family planning and use of birth control measures)
- *technological* adjustment mechanism (extraction of new energy resources)

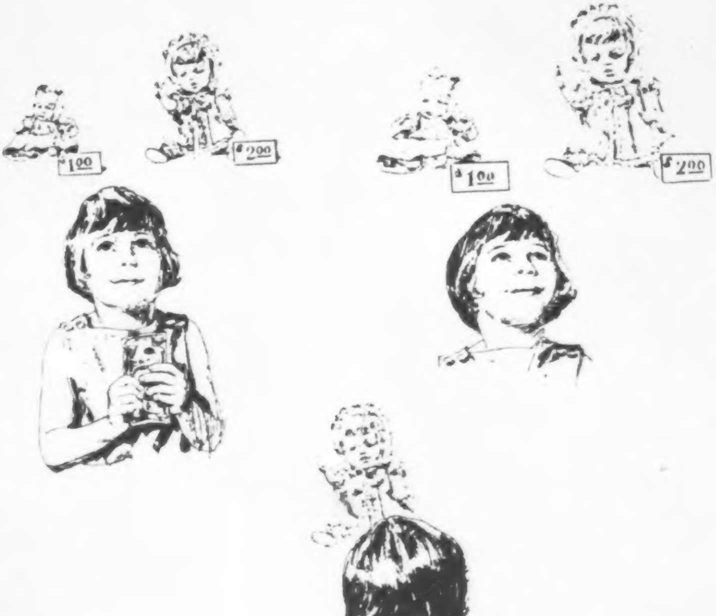
Only 12 percent of the materials deal with the economic system as a way societies can adjust and adapt; only 8 percent deal with political adjustment mechanisms. This seems a serious lack, as politics and economics offer vital opportunities for effective human intervention. As one scholar put it:

> One of my criticisms with a lot of the growth stuff is that it basically takes two extremes and tries to pull them together. It takes the planetary vision of interrelatedness and then it talks about the interpersonal appropriation of that planetary vision. And I'm saying that there's an awful lot that happens in between—and politics and economics are two major in-betweens. . . .
>
> For example. . .let's take the case of recycling raw materials. We can personally recycle aluminum cans until we're blue in the face. But if we want to really talk about recycling, then we've got to talk about how the political system penalizes the use of virgin materials and puts a tax on the front and back ends of the process—the front end being the acquisition of virgin materials and the back end the disposal of the stuff. Once you've put a premium—a tax on getting the virgin stuff and a tax on throwing it away—then recycling will become economically compatible. Without that, it won't happen.
>
> And I think the way to help people make a transition between the very big and the very small is to really start talking about what happens to those in-between structures, the political and economic institutions that people can relate to. . . .

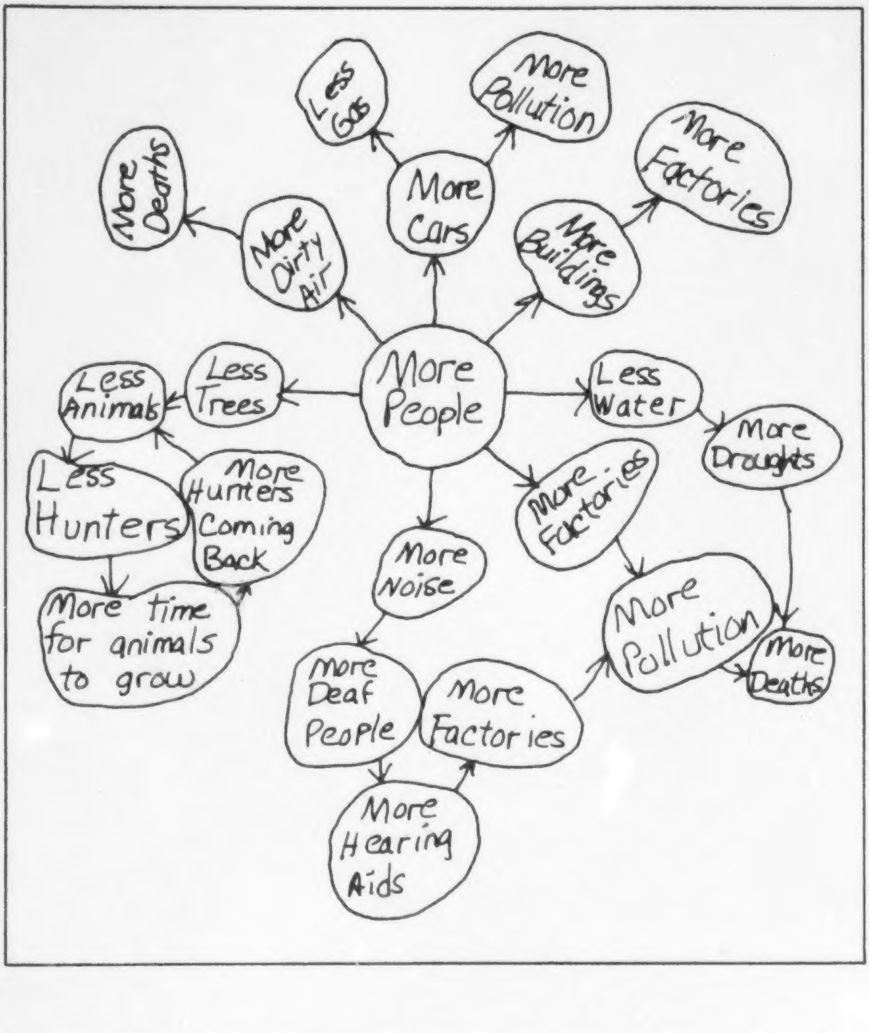
Another key concept—*biosphere system*—appears in over 40 percent of our sample. This concept is usually integral to biology, geology, ecology, and natural science curricula, but is found less often in social studies materials. Its high ranking may result partially from the high number of "science" materials reviewed (35 percent of our sample).

The idea of *limits* appears in 23 percent of the sample, but the concept is given different interpretations. Some materials (Hanvey's *Explorations in the Emergent Present; Science and Mankind* series) use a definition that parallels our own. In others, systems are viewed as having no finite limits—the United States, for example, is seen as able to feed itself always, and provide every person with a wide variety of foods.

As the following illustration from *Family Studies: Investigating Man's World* (Scott, Foresman) shows, *choice perceptions* and *trade-offs* are often discussed in terms of "postponement" rather than "I don't need/want more."



We were especially interested in whether *systems behavior* was presented: it is, in 15 percent of the materials reviewed. The idea of the interrelatedness of systems is handled imaginatively by a number of these courses. Futurists Jerry Glenn and Cyndy Guy use "Future Wheels" (see following illustration) to help fifth graders explore the ramifications of complex problems such as population growth.

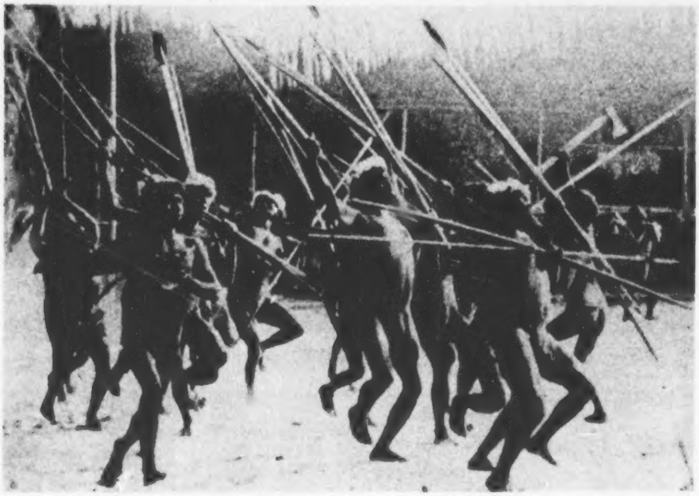

More People
More Dirty Air
More Deaths
More Cars
Less Gas
More Pollution
More Buildings
More Factories
Less Trees
Less Animals
Less Hunters
More Hunters Coming Back
More time for animals to grow
Less Water
More Droughts
More Factories
More Pollution
More Deaths
More Noise
More Deaf People
More Factories
More Hearing Aids

To start a Future Wheel, students write down the subject or topic that interests them, in this case population. Each student then draws a spoke from the central circle and lists a possible result of the initial idea. The process continues for several rounds as students explore additional consequences.

Nesbitt and Karls's *Teaching Interdependence: Exploring Global Challenges Through Data* offers teachers a variety of ways, such as the "Ocean Resources Game," to explore the concept of interrelatedness. Another imaginative effort that utilizes folklore and myths as well as case study data from societies around the world is *Education for a World of Change* (King, Branson, and Condon).

In many instances, however, courses that attempt to teach about systems focus solely on conveying concepts, giving too little consideration to content. For example, Sweeney's *World Environmental Concerns* (one of the first units on systems behavior developed for secondary students) clearly depicts the interrelationships of all aspects of the environment—ecological, political, technological, social, and market. But the book often presents limited factual data about a topic or subject while asking students to use this information to explore a complex issue.

For example, the following picture and accompanying caption are all the data students have about an unidentified South American Indian society.*



This picture shows life in a South American Indian society whose members typically eat spiders and other insects. Should the national government of this country force these people to improve the diets of their children by banning old food habits and forcing them to eat foods of better quality? Why, or why not?

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* We understand from the author that this text is being revised based on trial test feedback, and that the illustration shown here will not appear in the new edition.

Does this picture show "life" in a South American Indian society? Lacking other information, can students answer these questions without drawing potentially erroneous conclusions?

A similar problem occurs in other materials, as the following lesson, described by Roberts in *A Strategy for High-level Thinking*, shows:

> The secret of the Netsilik Eskimos' survival is their way of controlling the size of their population. If a baby girl is born and the family already includes a girl, the baby is usually given away or left to die. The Eskimos do this because the mother can only nurse one child at a time. A baby is nursed for two years among the Netsilik Eskimos. The family hopes the next child will be a boy and they cannot risk a three year delay. Boys are important because they can hunt for food, clothes and other necessities.
>
> The Netsilik Eskimo also lets old people die if need be. Old people just tag along and must be fed and clothed. If a family is having a bad time with food and [sic] the old one would definitely be left to die. In this way the Netsilik keep their populations balanced. The critical factor which determines the size of their population is the amount of food.*

This excerpt was all the information presented on the Netsilik to elementary students in this curriculum. Infanticide and senilicide are both highly charged emotional issues. To use such content to illustrate a complex, abstract idea (such as population problems) is to try to teach conceptual development without equipping students to deal with affective content. Also, to provide only two paragraphs about a society that discuss such an affective issue does not seem to give students an adequate understanding of the complex workings of that society. *The relationship of content to concepts is a difficult problem that current curricula about systems behavior have not dealt with adequately.*

Most of our key concepts were not used in all of the materials reviewed, as the table on page 76 indicates. Of those materials that did use a concept, 87 percent dealt with only one or two of them. No curriculum dealt with the full range of ideas we identified as important.

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* Roberts, pp. 164–165.

How Comprehensively Do Existing Curricula Teach About Food, Population, and Energy?

What We Looked For

We wanted to know if materials taught how biosphere systems operate at a concrete level. For example, was information provided that would enable students to describe what is necessary to produce grain and/or energy? We also wanted to know if materials taught about factors that might influence these systems. Did they, for example, discuss factors that might limit food or energy production? Did they discuss ways production could be increased or limited? Did they discuss points at which human and nonhuman intervention could affect the availability of energy and food to different people? Did they discuss the costs and benefits—both human and environmental—of various alternatives?

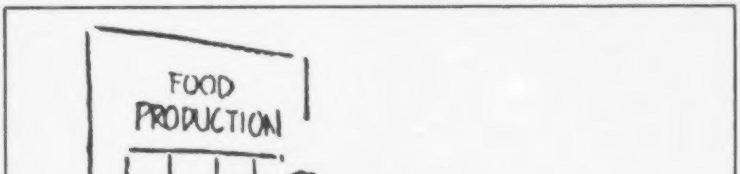
What We Found

An enormous quantity and variety of materials (print, film, games, coloring books) on food, population, and energy are available for every audience from primary school to adult. Most materials (such as Darlings's *Eco Systems*) describe carbon, water, nitrogen, energy, or food cycles. Biology texts (such as Kroeber, Wolff, and Weaver's *Biology*) tend to focus on the structural components of plant and animal life, whereas geology and ecology materials (for example, Andrews's *A Guide to the Study of Soil Ecology*) provide information on different soils and their potential uses. All materials emphasize the great amount of time needed to produce such fossil fuels as coal and oil.

Most materials on population deal with several types of information and themes. For example, many courses present statistical data emphasizing the exponential growth rate of the human population. Often, this information is linked to data about the effects of overcrowding on animal populations (depression, sterility). Only one item in our sample, *The Science and Ethics of Population Control: An Overburdened Earth* (The Center for Humanities) cautions viewers about the uncertainties involved in drawing conclusions about the behavior of human populations only from studies of animal populations.

Some materials such as *Environment and Population: A Sourcebook for Teachers* (Horsley et al.) discuss the relationship between human population size and distribution and the carrying capacity of the earth's ecosystem ("the threat posed by an expanding population on a finite earth"). Other items such as Pringle's *One Earth, Many People: The Challenge of Human Population Growth* aim to "convince readers that solutions [to population growth] must involve changes in our value systems." These materials then disucss the need for birth control and smaller family size.

Among materials that consider population and food together, a common theme is the discussion of technological developments—sea culture, the Green Revolution—that might solve the food-production/population dilemma. We were struck by the prevailing image in the materials reviewed that most U.S. food is produced by small, family-owned farms. Agribusiness is not presented as a major American industry. There is no emphasis upon the energy-intensive nature of American agriculture and its present levels of production; upon "diminishing returns" from increasing use of pesticides and fertilizers; upon the finite amount of good farmland; or upon the energy problems implicit in the fact that food production is geographically removed from the users' dinner tables. Food production and its distribution is presented as a problem for other countries, not the United States.



"Our study shows no danger of a food shortage. There will be plenty available for those who can afford it."

The relationship between population and food may be viewed in two ways. It may be viewed as a problem of "too many people" (that is, a need for better population control—or famine) or as a problem of inadequate distribution systems (that is, some get more than enough to eat while others starve). The overwhelming majority of the sample view the problem as one of too many people. The question, "Who has what and how is it distributed?" is dealt with in only a few materials' including "The Development Puzzle" and "Baldicer."

Materials on energy, such as the Federal Energy Administration's primary school booklet, *Energy Activities with Energy Ant,* tend to focus on the need for energy and possible ways to conserve it. Students are encouraged to cut down on their own and their families' direct energy consumption. But energy use in industry (and thus our indirect use of energy through consumption of manufactured goods) is not explored. The pros and cons of utilizing various energy sources (nuclear power, coal, oil) are discussed, but sources such as solar energy, wind power, and geothermal energy are not included as alternatives. There is no discussion of renewable vs. nonrenewable energy sources. And the various energy "qualities" involved (electricity, for example, is more versatile than sunlight, water, or nuclear power) are not presented. Many materials provide a slim data base, then ask students to weigh the costs and benefits of complex energy alternatives. For example, in Pollack's *The Conservation Story,* only three pages deal with strip mining. Yet students are asked to discuss in detail the short- and long-term ramifications—both for the land and the people—of this type of resource extraction.

Only a few courses (Odum's *Energy Basis for Man and Nature,* and Guidance Associates' *Global Emergency: Food and Population*) discuss in detail the interrelationships among food, population, energy, people, and the environment. Most materials tend to focus on a subsystem, such as food webs, nested within the larger system.

Do Materials Attempt to Teach Problem-solving Skills Applied to Growth and Survival Concerns?

What We Looked For

To become effective citizens, students must learn to assess growth-and-survival issues: to identify the systems containing problem behavior; to create and use hypotheses; to gather relevant data. They should learn to propose and choose solutions, and to weigh the costs and benefits of alternatives from several viewpoints. As adults, they will need to engage effectively in advocacy based upon their own assessments and decisions. They need to be able to identify their own roles, both in contributing to growth-and-survival problems and in finding solutions. The development of such skills should be an important theme of all curricula.

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What We Found

About one-third of the materials ask students to *assess the extent of predefined problems* (overpopulation, depletion of nonrenewable resources). The following table shows the percentage of materials that stress skills we identified as important for an understanding of growth-and-survival issues. It should be noted that even among the 18 percent that provide opportunities for students to practice problem-solving skill development, most focus on data gathering rather than analysis or consideration of costs and benefits of alternative solutions. For example, although the primary goal of Johnson and Mann's *EcoLab* (an elementary course for studying the rural and urban environment) is "to involve children in inquiry and problem solving," the materials ask students only to gather, not to analyze information.

Key Skills Stressed in Materials

No. of Items	Percentage	
46	33	Assessing existence of problems (Assess extent of predefined problems)
27	19	Identification of own role in cause and solution of problems
26	18	Problem-solving skills (problem identification; creation and use of hypotheses; data gathering; analysis; design of alternative solutions; consideration of costs and benefits from several points of view; choice of solutions)
19	13	Advocacy
19	13	Making and evaluating projections
6	4	Systems analysis

Materials focusing on systems-analysis skills (4 percent) tend to describe how a system works (food webs, energy cycles), rather than enable students to create and evaluate their own models. One teacher, who developed an entirely new environmental studies course for his high school students, said:

> Most of the materials on the environment just say what's there. They focus on having kids discover the relationship between things—like food webs. But every student should be exposed to the idea of limited resources and to thinking about alternatives—and you don't do that just through studying food webs. Also, by focusing on typical [systemic] problems any community must face—food resources, water, and air pollution—no matter where students live as adults they will be better able to think about and deal with these issues. [My students] are now learning the processes and ways of thinking about these problems that will be useful throughout their lives.

Although 19 percent of the materials emphasize "the identification of one's own role in the cause and solution of problems," it is difficult to interpret this index since "cause" and "solution" were tallied together on our review form. However, it appears that more materials focus on the role of people as destroyers of the earth's resources than on their role as solvers of the earth's problems. For example, in the CBS film *Environment*, five citizens (housewife, construction worker, power plant official, farmer, white collar worker) are kidnapped in the middle of the night to stand trial; they are charged with degrading the environment. The film graphically illustrates how each individual contributed to the land's destruction. At the conclusion viewers are asked: Which person is the most guilty?

A few materials do present positive models of human resourcefulness so that students can identify not only their role in causing problems but also in finding possible solutions to problems. One effort in this direction was made by the NEA. *Energy Choices Now: Saving, Using, Renewing* presents a variety of viewpoints to help students "analyze, evaluate, and decide upon the energy alternatives open now and in the future." Another course, *Critical Issues in Science and Society: A World to Feed* (The Center for Humanities) deals with several possible methods of solving the problem of world hunger. In the National Geographic Society's *National Parks: America's Legacy*, students have an opportunity to determine their own needs and values before role playing alternative proposals for national parkland use.

Only one or two courses emphasize *problem identification*. *Investigating Your Environment* (Biological Sciences Curriculum Study) asks students to choose an area of interest and study whether an environmental problem of concern to them exists in that area. The materials, however, do not teach systems analysis, making and evaluating projections, advocacy, nor identification of one's own role in the cause and solution of problems.

It should be noted that 26 percent of the courses sampled do not stress any of the key skills; instead, they emphasize only the conveying of data and information.

What Values and Attitudes Do Materials Present?

What We Looked For

People approach the teaching of environmental concerns and the history and future of world development from a range of value positions. We were interested in identifying prevailing attitudes toward growth, technology, limits to growth, responsibility for the future, and the place of the individual in the biosphere and ethosphere. We wondered if materials communicate a sense of personal empowerment or hopelessness. Do they enable students to participate in decisions about the future? To what extent are students encouraged to see themselves involved with others—in their community, in the nation, and as part of an international, interdependent world? Do any materials try to promote a desire for a life style that is less dependent on extensive use of finite resources and more self-sufficient?

What We Found

The following table shows the values and attitudes that seem to be fostered by the materials reviewed.

Values and Attitudes Emphasized

No. of Items	Percentage	
47	34	Responsibility for the future
40	28	Acceptance of limits
33	23	Sense of identity with (place in) the ethosphere and biosphere
23	16	Sense of empowerment
17	12	Sense of involvement in community
12	9	Sense of involvement in world
11	8	Technology will save us ("Increased technology is the answer")
11	8	Sense of involvement in nation
9	6	Sense of hopelessness
3	2	Sense of satisfaction ("I don't need/ want more")
3	2	Pleasures of pruning down ("I can be happy with less")
3	2	Growth is necessary and good

Responsibility and Empowerment

The attitude stressed most frequently is that students should see themselves as having responsibility for the future and the environment (34 percent). This attitude usually implies making choices with an awareness of their ecological implications. However, in many cases these implications are not presented fully nor linked clearly to choice making. For example, in the Prentice-Hall *Contours* series, students are told, "Only your actions and the actions of others like you can lead to effective change. . . . You should become the type of person that is desperately needed to help restore and maintain [the environment]." Yet students are never provided with opportunities to use the scientific understandings they gain in the program to think about the implications of future choices they might make. Many curricula tell students, "You can make a difference in the future; you have many choices; you can do something to stop the waste and pollution of our ecosystem." But they do not go beyond that exhortation to provide instructions or opportunities for students to exercise choice and develop skills for stopping waste or pollution. Thus, many curricula simply charge students with responsibility without providing means or models for assuming responsibility and affecting the future. Only about 16 percent of the sample stress building students' sense of empowerment.

Few curricula discuss the pleasures or benefits from "pruning down" one's life style or holding personal consumption and energy use to a minimum. One book that does, Mark Terry's *Teaching for Survival,* includes ways students can contribute to sustaining the environment and reducing energy consumption. Terry suggests personally relevant activities such as:

- collecting information about how much energy household items consume (oven, reading lamp, electric blanket)
- inventorying personal household or school energy use or contribution to wastes
- determining personal priorities in value-clarification activities. (List and rank ten things you like to do. If you are cut back to five of them, which will you choose? How will the change affect your life style?)

A few curricula, such as the Brockton, Massachusetts, and Port Huron, Michigan, programs, set tasks and projects to contribute to solutions. In the Port Huron program, students research the needs of their community in relation to the proposals that are before their Town Council. They then present their findings and recommendations in a formal report. Students' investigations have ranged from "Should the Township give up 600 acres for annexation to Port Huron City for industrial expansion?" to "The Needs of the Aged in the Blue Water Area." However, in most materials "empowerment" means giving students incentives simply to cut down personal consumption; and doing so does not appear in the positive context of personal benefits to be gained. This omission presents a key problem, for psychologically students may "tune out" distressing information that is presented without potential solutions.

Identity with Biosphere and Ethosphere

About 23 percent of the sample emphasize student identification as participant in the ethosphere and biosphere. In general, however, the materials pay scant attention to the individuals' sense of identity and place in the social and physical world. The exceptions are materials that concentrate of values clarification. However, in the materials on values, emphasis on personal development is not coupled with an attempt to relate that process to learning about the social and physical systems surrounding the student.

Sense of Involvement

Materials stressing personal involvement in the community, nation, and world are not numerous. The value of community involvement is stressed slightly more (12 percent of the sample) than is world involvement (9 percent). Community involvement tends to be translated into action leading to community work or research (for example, studying local river systems), whereas world involvement is more abstract, often rhetorical, and sometimes misleading. For example, world involvement through simulation in the game "Meridian 36" means "capturing" portions of a world map in order to "control" population growth and "life-sustaining elements"—a process that encourages players to solve problems by achieving superior power over land and people, or "playing Napoleon." Another game, "Baldicer," however, stresses cooperation among nations and increased technology as a means of achieving global survival.

Technology as a Solution

Except for food production and new resource development, the idea that technology is a possible answer is not stressed by many materials. However, we did find faith in technology, "tempered by man's wisdom," expressed frequently as a major way of adapting to shortages and environmental degradation. Another frequent theme, often paired with this assumption about the positive value of technology, is the value and necessity of reducing population growth. The need for fewer people—rather than a more equitable distribution of resources—is widely [illegible] as the espoused solution to scarcity.

Valuing "Nature"

A recurrent value theme that emerged in our study (especially in ecology, biology, and environment/conservation materials) is fostering appreciation and respect for the earth. *Exploring Urban Plant Life* (Cooperative Extension Services of the Northeastern States) teaches students not to scorn the weeds and plants of the city; they too are worthy of study and enjoyment. Another theme is that nature should be studied and loved for its own sake. Other curricula stress the value of gaining intellectual understanding of the principles of ecology, of applying scientific inquiry to aspects of ecology. Still other materials stress the importance of the scientific method and provable reality as a way of understanding life. They couple this theme with appreciating the wonders of nature.

Academic Values

In analyzing curricula materials, a value position not originally identified on our review form emerged in a large number of courses. Many texts emphasized mastering "hard" facts and data. Attempting to be "value-free," these materials ignore or obscure people's relationships to the issues being presented. For instance, population materials tend to present data-istic "solutions" to avoid confronting the sensitive issues involved in efforts at population control. Students are inundated with impersonal information. Such an approach may encourage what many have come to call "a head trip"—intellectualization divorced from personal involvement.

Identifying Values

Despite emphasis on *values clarification* in many of the materials, we found few cases where authors were explicit about the values that had shaped the course they were presenting. An exception was EDC's *People and Technology: Acquiring Energy*. The predominant value orientation of other materials is implicit in a variety of ways: the kinds of questions and activities included, the statement of goals and challenges, the warnings and exhortations and the kinds of words chosen—such as references to "courageous Margaret Sanger,"* or to future populations as "the additional mobs who will inhabit our cities." But values are not identified directly nor explained to teachers and students.

Stated goals are sometimes belied by values implicit in the materials themselves. For instance, one game called "Economic System" (Coleman and Harris) encourages a positive view of unlimited growth by telling players that "the object of the game is to gain the greatest satisfaction through consumption of food and manufactured goods." The winner is the person who consumes most. Players are also told frequently, "You do not get points for having money: only for consuming food and manufactured goods." Similarly, players get no points for holding on to their own labor. Their labor is valuable only when sold to someone else: "Any hours of labor you do not sell cannot be saved. You will hand them in to the Scorekeeper and get nothing in return."

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*Pioneer in the Planned Parenthood movement.

Value positions are generally taken for granted by developers in preparing materials. When value positions are stated explicitly, they are usually presented as facts or imperatives:

> The United States should insist that underdeveloped countries control population and nationalize all lands owned by wealthy inhabitants in order to grow food for the poor.*

How Do Materials Handle Potentially Upsetting Issues?

What We Looked For

Depression, frustration, disorientation, guilt, fear, outrage, hopelessness, and defensiveness can all be triggered by serious teaching growth implications and global survival. We were interested in learning whether authors and developers acknowledged the presence of problematic and emotionally charged content in their materials, and whether they made provisions (in student and teacher materials) for helping students cope with difficult emotions and threatening issues. What kinds of acknowledgment and assistance are given to help students deal with their negative reactions?

What We Found

Most materials in the sample seem likely to affect student values and beliefs greatly. However, only a handful make provision for dealing with their potential emotional impact. Less than 10 percent address teachers on such issues, either to prepare them or to help them watch for signs of disquieting or upsetting impact on their students. One course that does recognize this need suggests only that the teacher "listen sympathetically" to worries students express. Even fewer curricula (n = 5) face the issue directly in student materials. An exception, the guide for "Baldicer," offers suggestions for handling hostile feelings that might arise as players try to keep the countries they represent from losing out in the struggle for global survival.

About 16 percent of the materials we examined avoid raising any potentially upsetting issues. In these cases, one or more of the following characteristics were present:

- impersonal academic analysis and study—for example, a demographic viewpoint, or a specialist's examination of nature,

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*Center for Humanities, *Critical Issues in Science and Society: A World to Feed*, p. 11.

technology, or human behavior—promotes intellectualizing and distancing rather than personal involvement

- concentration on busy work and collecting data without exploring the reasons for the work or the wider implications of the information amassed avoids emotionally difficult issues
- an upbeat, light-hearted tone and presentation counteract student worry

There is a great need for materials that do not sidestep emotional issues but help students and teachers deal with them in positive ways. An educational program to help tomorrow's citizens improve and sustain their environment (both social and physical) must include ways of helping students deal with the frustrations that arise when they are exposed to the large picture of interrelated systems. They are likely to experience conceptual overload: "I can't understand it." "I can't do anything." "It's beyond my scope." In the words of Dennis Meadows, the crucial question to keep in mind while developing such a program is, "How can you help kids respond constructively to the overwhelming knowledge?"

How Comprehensive Are Individual Programs in Providing Multiple Modes of Learning?

What We Looked For

On the assumption that different learners need different methods of instruction, and that comprehensive learning for any individual is most effective when several means of acquiring and internalizing information and ideas are available, we looked to see whether materials offer students a range of learning strategies. Were reading, discussion, gaming, hands-on experiences, research and action projects, and other strategies combined in an attempt to balance and reinforce learning? We were also interested in finding out if courses could stimulate interest in the future of the environment and the species without relying on scare tactics.

Finally, we wanted to know to what extent learning strategies enable students to find out about local concerns and conditions. What techniques had developers of curricula with a national focus found for involving students in their immediate surroundings? Did materials developed locally under Environmental Protection Agency or Office of Education funding include approaches that could be used elsewhere?

What We Found

Many materials take the form of lesson outlines, lists of resources, or collections of suggested activities. Thus, tallying the types of pedagogy recommended in the materials was difficult. If a material recommended a film, for example, but left the teacher responsible for acquiring it and carrying out the suggested activity, we did not cite "film viewing" as a part of what that curriculum provided. If role-playing, debating, or another activity is suggested but not developed, either through student materials or instructions to teachers, we did not consider that pedagogical method to have been used "extensively."

Such judgments had to be made throughout the review of these very disparate materials. An additional difficulty in assessing methodological balance arose with respect to curricula that consist of a collection of strategies for teachers to choose from—for example, the *Environmental Educational Activities Manual* (Stapp and Cox) and the *Handbook for Environmental Educational Strategies* (University of New York). Lacking guidelines or suggestions for sequencing to help teachers create their own balanced course, these often rich materials offer many possible modes of learning but give no clue about which modes teachers may select and which they may leave out. Most teachers need and want help in learning how to carry out a larger repertoire of teaching strategies. Without that assistance, most teachers will probably not use novel approaches. When no program of teacher training accompanies the materials, teachers are likely to stick to familiar instructional modes.

Finally, many materials consist of only one or a few activities designed for inclusion in courses teachers may already be offering—for instance, Mastrude's *Teaching about Spaceship Earth: A Role Play Experience for the Middle Grades*. We can only hope that the intended learning is reinforced by the other activities and resources provided by the teacher.

Pedagogical Strategies

Given these qualifications, the following table shows in rank order the incidence of learning strategies we found in the sample.

Pedagogical Strategies Used

No. of Items	Percentage	
66	46	Reading
57	40	Class discussion
56	39	Small-group discussion

27	19	Classroom experiment and hands-on ecology
26	18	Research
24	17	Role play
23	16	Structured questions and answers
19	13	Games
17	12	Filmstrips, slide shows
17	12	Case study
17	12	Debate
16	11	Field trips
12	9	Community action
10	7	Film viewing
7	5	Guest speaker
4	3	Individualization (Individualized learning)
1	1	Apprenticeship

Almost half of the materials depend heavily on reading and discussion.

Although research is encouraged by about 18 percent of the sample, little assistance is provided in most cases for guiding and assisting research efforts. "Research" tasks range from traditional library research in areas such as population growth, energy use, or the causes of the Depression, to analysis of pollution or land use in one's own community. The combined category of classroom experiment and "hands-on" ecology appears in about 19 percent of the curricula, mostly science courses.

Although some course outlines and suggested activities recommend films or games, few courses *include* films or games as part of a full program.* The four or five exceptions include the National Geographic Society's *The National Parks: America's Legacy;* and Scholastic Magazine's *Dimension Environment*. The films and most of the games reviewed were created as separate entities, usually accompanied by a two- to eight-page guide.

Few curricula employ a wide range of learning modes. Most depend on combining discussion with one to three other approaches. Those that clearly seek to offer a multimedia experience include the comprehensive Harcourt Brace Jovanovich series, *The Social Sciences: Concepts and Values*. Others are Scholastic Magazine's *Dimension Environment* (materials designed for young children to stimulate interest in the environment) and EDC's *People and Technology* program.

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*This is probably due to the high costs of developing such materials and the difficulties many schools operating on constricted budgets have in purchasing these resources.

Stimulating Eco-consciousness

To awaken concern for the environment and/or issues of future survival, about one-third of the curricula use data about the present, past, or future. The second approach used frequently is a scare technique: "We are all doomed. By the year 2000, earth will look like a moonscape." This frightening or threatening approach is sometimes combined with fantasy or imagery as in films like *Tilt* (National Film Board of Canada), *Tragedy of the Commons* (Holt, Rinehart and Winston), and *Environment* (CBS).

Approaches to Arouse Eco-consciousness

No. of Items	Percentage	
39	27	Data about future, present, and/or past
30	21	Threat/fear
19	13	Models of positive approaches others have taken
16	11	Fable/imagery
16	11	Field trip
14	10	Fantasy
4	3	Student projects in the field

Stimulus through fantasy takes the form of role plays in some materials, such as "Eco-Act—a Role Playing Game to Clarify Environmental Values," developed by the Environmental Education Project at the University of Florida, Tallahassee. Stimulus through fantasy also takes the form of books like Theobald and Scott's novel *Teg's 1994*, and Stadler's *Eco-Fiction*, a collection of writings that includes fables as well as fantasy.

Threat, fable/imagery, and fantasy are sometimes combined in one curriculum, and sometimes augmented by data presentation. Models of positive approaches to eco-consciousness are present in only about 13 percent of the courses.

Local Adaptability

Almost one-quarter of the materials under review try to tie learning to the students' local surroundings. Most suggest such activities as taking soil samples, interviewing local citizens, inventorying energy uses in their homes or school, or tracing the history of land development in their town. Some programs, like *The Web of Life Around Longfellow Pond* (Wellesley, Massachusetts, public schools) are built around training local volunteer "environmental aides" who take children on a local field trip to examine natural and human resources and history. The unit for Acton, Massachusetts, fourth graders, *Acton: A Study in Community Development*, combines local history with present-day data collection, and emphasizes field trips. The futuristics course developed in Port Huron, Michigan, and the environmentally focused *Project Quest* in Brockton, Massachusetts, lead students into advocacy roles in their community after careful study of the social and physical systems around them.

This dimension of local application is largely lacking, however, in courses designed for national distribution. But a start in this direction is evident, for example, in ideas for activities offered by Mark Terry and by Stapp and Cox. Their suggestions could stimulate teachers to have their students explore macrocosmic issues in the microcosm of their community. These ideas for local activities are as yet only outlines; more structure is needed in order for teachers to carry them out, and to cope with complications that can arise when students investigate policies or plans in their own community.

Beginning efforts in this direction are the national curricula developed by the Biological Sciences Curriculum Study (BSCS) and by the National Environmental Educational Development (NEED), which provide promising approaches for investigating local environmental concerns. As one teacher told us:

> It's very important to use local issues and local resources. For example, if you're doing a unit on botany, get members of the local garden clubs to supply specimens and talk with the kids. Today it's really crucial that the community be involved in schools! For example, in my classes students for their environmental education project link up or ally themselves with an organization, individual or group who is interested in or will be affected by data they obtain. And teachers are now more interested and willing to send kids out into the community—not just to do something, but to have them really learn.

How Comprehensive Are Individual Programs in Terms of Giving Teachers Sufficient Support to Enable Them to Reach Course Goals?

What We Looked For

Did materials provide teachers (through guides, seminar programs, and evaluation assistance) with sufficient assistance for carrying out assigned activities; for helping students discuss issues and seek answers to questions raised; for evaluating student progress; and for adapting to local conditions?

What We Found

More than half of the sample have no teacher's guide; several more are accompanied only by a few pages of instruction. A transcript or summary of a film or filmstrip with five or six discussion questions is often included in media packages. Most materials, however, give no assistance for evaluation of student progress or course effectiveness. We found only three courses that include teacher training elements such as workshops or training tapes: the Florida State University Title I-funded *Community Leaders Training in Environmental Studies;* EDC's *People and Technology;* and EDC's *Unified Science and Math for Elementary Schools* (USMES).

Guides

Some guides are quite thorough and helpful in providing assistance for teachers in reaching course goals—for example, Allyn and Bacon's annotated teacher's version of their *Biology* text and the teacher's guide to *Technology: Promises and Problems* developed by the Educational Research Council. In addition to offering general background perspectives on topics covered in the texts, both guides offer specific suggestions for dealing with questions in the texts and for carrying out the activities. Neither program seeks to involve students in their communities, and neither tackles a comprehensive view of growth implications. Given the limited objectives of these courses, teachers are likely to find the support offered adequate.

Of the other materials reviewed, about 15 percent address themselves only to teachers; no materials are provided for students. Many of these guidebooks are very evocative, making the reader eager to begin developing the ideas for use immediately with students—for instance, New York University's *Handbook of Environmental Strate-*

gies, or the delightful *Operation New York* (Bureau of Curriculum Development).

Some handbooks and source books include not only practical "starters," but also background readings, tabulated data, and, occasionally, tear-out pages that can be reproduced for use with students. The *Intercom* publications by the Center for War/Peace Studies and Fyson's *The Development Puzzle: A Source Book for Teaching About the Rich World/Poor World Divide* are examples of such promising starts.

Many handbooks contain only one or a few activities for teachers to add to existing courses, to stimulate interest in human use of the environment, or to introduce issues such as population growth. Still other teacher-directed materials are simply course outlines that provide neither teacher nor students with the necessary materials for conducting the described activities.

Evaluation Strategies

A summary of the types of evaluation assistance that we found in the curricula is given below:

Evaluation Components Provided

No. of Items	Percentage	
11	8	Courses offer sample tests
9	6	Courses offer questionnaires
6	4	Courses offer observation forms or guides
4	3	Courses offer general suggestions for evaluation

About 92 percent of the sample provide no evaluation assistance. The evaluation assistance that is included is evenly divided between materials that are student-focused (leading to self-evaluation and assessment of the course) and those that are teacher-focused.

Teacher Training

The element most absent in teacher support is planned linkage to a teacher training program. Our reading and our conversations with practitioners suggest that this void has been partially filled by regional environmental centers (at least while federal funding is available) and by other local institutions, such as science and natural history museums (where such are available). In the words of the director of one such institution:

> Right now teacher education is our highest priority. There's a plethora of materials, but teachers don't know how to teach them; it's up to organizations to see if there really is a need for new materials, and, if so, to develop them. But then you should focus on getting them used in the classroom, on helping teachers to teach them. And you need a mechanism for reinforcing it. For example, after we have teachers all jazzed up at a workshop, what happens once they go back to the classroom?

It seems clear that the field of growth implications and the earth's future needs teacher pre- and in-service preparation and continued support. Opportunities are needed to help teachers learn from the experiences of others, and to incorporate new developments and skills—systems theory, futures research methodology, and the "growth debate" literature—into their teaching.

Our review also has shown that teacher training curricula have a responsibility to prepare teachers for difficulties they may encounter in teaching about local issues and problems. Teachers should be given strategies for coping with community reactions to teaching about growth implications or about what may become controversial community issues. Teacher guides, evaluation strategies, and training opportunities all need to deal with this sensitive aspect of studying the environment and growth implications. Another experienced teacher trainer and program director in the field put it this way:

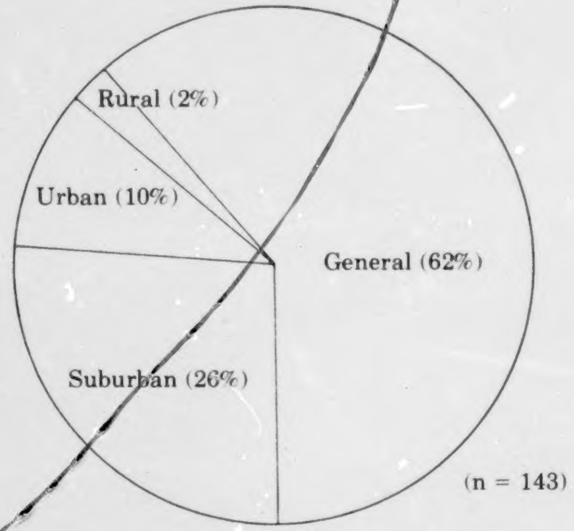
> We know that kids are most interested in things that concern them locally. We know too that these issues don't become national problems (such as pollution) until there has been a default at a lower level. Kids have to know what's happening round them. That's where you should start—it's what kids are interested in and can most easily relate to. But teaching local issues is a high-risk area. You have to help teachers teach what can become very controversial issues.

In the materials reviewed, teacher support does not address the full context of implementation—how to work with administrators and the community, what the role of either might be. Even working with other teachers, a key issue especially at the secondary-school level, is barely touched upon.

To Whom Are Existing Materials Addressed?

What We Looked For

Materials are needed that speak powerfully to young people from many regions and walks of life—from urban, suburban, and rural backgrounds. We were interested, therefore, in knowing whether materials had built-in assumptions about student life styles or economic status, and whether curricula addressed the interests of students from different regions and living conditions. We also looked for materials that would not be limited in perspective to students in the United States or other highly technological nations.



What We Found

As the chart indicates, the majority of curricula in our sample (62 percent) are designed for use by a general audience (i.e., urban, suburban, and rural). Materials aimed only at suburban groups (26 percent) tend to reflect and address one life style (single family dwelling, two parents, two children, many possessions) to the exclusion of others; or, in the case of science courses, to describe field trips and "hands-on" ecology experiments (often involving expensive scientific equipment) that could only be done outside a city environment.

Issues of particular concern to urban dwellers, such as lead poisoning and substandard housing, are not emphasized.

Another question we investigated was the extent to which materials could be adapted for international use.* We found that 43 percent could not, primarily because of stereotypic expressions or phrases used to describe the peoples and countries of Africa, Asia, and Latin America. For example:

- "have-nots," "underdeveloped," or "undeveloped"
- "irresponsible, superstitious, and ignorant"

  —"People of the have-not nations are prevented by ignorance and cultural and religious traditions from taking advantage of birth control methods that people in the advanced and affluent countries take full advantage of [sic]."

  —"Who is going to fill the grocery cart of a country that is daily compounding its own problems?"
- "full of starving people—mostly black children"
- "primitive societies," "natives already practicing infanticide"
- "don't value human life" (because they have so many people)

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*As far as could be determined, 94 percent of the curricula were written by Americans. All but two were published in the United States.

Conclusions

When we put together the results of our student interviews and the results of our curricula review, what did we find? We have organized the findings in terms of seven areas that became salient during our analysis of student thinking and curriculum materials:

- student differences
- systems skills and holistic perspective
- connections—future/present/past and community/nation/world—and self
- realities of food and energy availability
- problem identification and solving skills
- the role of human resourcefulness
- pedagogy and teacher preparation

Student Differences

We were continually surprised by the lack of difference grade level (seventh, ninth, eleventh) seemed to make in student attitudes, knowledge, and ability to handle concepts and skills. One hypothesis offered us about this lack of difference is that the main source of information for students is the media (television primarily) which tend to focus on issues that become newsworthy (e.g., spray cans and the ozone layer) and to provide similar data. Students seem able to handle requisite concepts and skills as early as seventh grade (and some of the interesting experimental efforts are targeted at earlier levels, first, fifth, and sixth grades). Thus, seventh grade (if not earlier) may be a good level at which to begin a systemic approach, so that students have been exposed to systemic thinking before entering secondary-school science and social studies courses.

Differences across sites were more evident than grade-level differences. Suburban students tended to focus on global future issues of war or overpopulation, while urban students focused on immediate issues of violence. When asked specifically about the future, suburban and rural students seemed inclined to see the problematic side of growth and technological advance. Urban students, on the other hand, tended to have science-fiction views of the future bearing little resemblance to the violence and pollution that characterized their view of the present environment. They did not, however, foresee an active role for themselves, either as participants in an "appealing" future or in the task of bringing it about.

At the Planning Conference held in October 1975, Earl Craig, Director of the Urban Coalition of Minneapolis, noted that urban teenagers "have so many real worries about the problems of today that they can't afford to spend their energies on the problems of tomorrow." It is unfortunate that curricula do not make clear how tomorrow's problems are already today's problems, and how immediate intervention can make a difference.

Systems Skills and Holistic Perspective

The creative experimental teaching efforts we studied suggest that students can develop systems thinking skills at least as early as seventh grade. Suburban students did show a greater tendency than rural or urban students to think in terms of systems: they expressed some understanding of the interrelationships of various elements making up the world. But given our small numbers, this difference may simply reflect the uniqueness of the particular school in which we interviewed, or the academic preparation of students in our sample.

Only 4 percent of the materials reviewed deal with systems analysis, and these usually describe what a system is rather than provide opportunities for students to create and evaluate models of systems themselves.

A few promising starts in teaching systems thinking merit further development and integration into other curricula. Surprisingly, two of these were at the elementary level: Nancy Roberts's research on teaching high-level thinking and the "future wheels" used by Glenn and Guy. There were also two at the secondary level: Robert Sweeney's *World Environmental Concerns*, and *Project Quest*, developed by teachers at Brockton High School, Brockton, Massachusetts. These courses not only attempt to teach systems thinking but also to build on it for problem solving.

On the more general issue of a holistic perspective—that is, a continual awareness of the interplay of whole systems—we found that most materials failed because they focus on only one issue or analyze a situation from the viewpoint of only one discipline. While we recognize that focusing on one issue or one set of factors may be necessary for analysis, it is also necessary to step back and view the whole system, or step into other vantage points, in order to understand the systemic nature of situations that confront us.

What students may need in order to deal with growth issues is the ability to make conscious and flexible shifts among perspectives adopted for the study of a problem. That is, they may need to know when they are looking at a piece of a problem and when they are looking at the whole. They may need to see the boundaries of the whole question, and also to learn how to choose perspectives for a given task.

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Connections—Future/Present/Past and Community/Nation/World—and Self

Future/Present/Past

Student predictions for the future varied greatly; this is one of the few areas where we encountered major differences across sites. As noted, suburban and rural students expressed concern about the future—nuclear holocaust, overpopulation, pollution—while urban students tended to conjure visions of a future world improved by technology. They imagined cities under water and individuals flying singly through space. But all students, regardless of their visions of the future, failed to make connections between their visions and the impact such visions would have on their own lives. The possessions most students hoped to own and the life styles they anticipated were affluent and energy-based. The only limits they foresaw were economic: their individual ability to get jobs and pay bills. They did not link economic limits to natural (resource) limitations.

No curricula significantly integrate past, present, and future time perspectives. Materials focus well on one or another, but not on all three:

- the distant past (the great amount of time required to produce fossil fuels), or sequential history (the changing face of a town, the causes of the Depression, the history of science) OR
- the present (investigating local land-use in your community, visiting a nature site) OR
- the future (thinking about the future by using techniques of forecasting, scenario writing)

Generally curricula are not "future responsive"; they do not clarify the role of past and present events in affecting what will and will not be possible in the future. One way to treat energy conservation in a future-responsive manner would be to make students aware that fossil fuels, once used, are gone forever. For example, (in a sense) the light you get from a light bulb now (from fossil fuel now) is light (energy) you or someone else may want very much at some future time that may not be available because it was spent *now* rather than saved. Integrating time perspectives in a future-responsive way means perceiving all Nows (past, present, and future ones) as:

- partly shaped by prior actions (our own and other peoples)
- partly within our capacity to shape now
- partly uncertain, unseen, and unforeseeable (because still hidden or potential in our future)

Global Connections

Just as most curricula do not make future-responsive connections in time, connections across the earth were either problematic or lacking. Forty-three percent of the materials present a negative and/or stereotypic view of peoples and countries of Africa, Asia, and Latin America. They convey little value for people of preindustrial countries, viewing them as passive and backward. Most of the remaining materials do not include a global perspective at all. Only 12 percent

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seem to foster a sense that students are personally involved in the problems and solutions that affect the world. Rarely do materials help students perceive common interests shared by the United States and developing countries.

Issues are presented as global or national or local; the implications of any one issue are rarely spelled out for all three levels. Exceptions are *Teaching About Spaceship Earth*, a role play from the Center for War/Peace Studies, and *The Development Puzzle*, by Nancy Lui Fyson. These materials propose student activities that link student learnings from playing a global game to concerns in their own communities.

Connections to Self

Materials rarely make explicit connections between course issues and students' lives, on either conceptual or affective levels; most successful in this respect are materials that focus on local issues. Local applicability of concepts is crucial, but hard to accomplish in courses developed outside the locality. And, as noted, materials focusing on local issues do not present the broader, national and global picture. Methods do exist for developing effective connection-making awareness, and these need to be replicated for other contexts and other teachers.

Teachers need assistance in dealing with the emotional effects of growth-and-survival issues on students. First, teachers need to recognize the value issues in a curriculum. In our curriculum sample we found that forthright identification of underlying course values is rare. Curricula that relate to predictions and policies for our future survival cannot be "feelings free" or "values free"; nevertheless, many materials attempt to be "values free" by focusing on mastery of "academic disciplines" and ignoring or obscuring the student's personal relationship to the issues being presented. Materials lack exercises that arouse caring on a concrete, personal level. As a result, students either may not care personally about the issues, or may care but receive no help in dealing with the concerns they feel. One kind of exception to this is an exercise in *People and Technology* in which students carefully design and build a village that they will later flood when studying the effects of damming a river. (Students often become upset about destroying the village, and subsequent class discussions focus on emotional as well as cognitive trade-offs, which now mean something to the students.) Some materials focus well on feelings and values clarification (the *Values Education Series* by Rodney F. Allen, for example) but do not integrate values clarification exercises with other course content.

The student interviews indicate that questions about growth and the earth's future are viewed in a religious framework by some students and engender religious concerns. Some students we interviewed saw the impending ecological crisis as a fulfillment of predictions of the end of the world. None of the materials sampled offer any help in responding to religious concerns.

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Realities of Food and Energy Availability

Generally students were aware of the problem of pollution and of present and impending shortages in food, energy, and other resources. Many saw shortages as short-term rather than long-term. Few students related shortages in one community to shortages in another, or indicated awareness of the idea of finite limits on resources. Nonetheless, their views of our society's ability to resolve problems of pollution and future shortages were bleak. They saw the causes of these problems to be overpopulation and human greed. As solutions they proposed:

- control of population growth and consumption, backed up by severe punishment
- taking steps as a society to conserve energy, hopefully in time

The only time students talked positively and confidently about science was when they were conjuring up science-fiction visions of the future—"moving sidewalks," "underwater cities." Science and technology were rarely mentioned in response to ecological problems, and then only with respect to energy problems—never to food or other resources. In general, students do not appear overconfident about technological "fixes"; technological approaches occurred to very few of them.

Students seemed unaware of the range of alternatives in agricultural production, in nutrition, and in patterns of food distribution. They also seem to be unaware of some basic elements of the processes. For example, when asked what is needed to produce food for people, students mentioned soil and climate and made no mention of human elements such as labor, technology, or distribution.

In the curriculum sample, we found gaps similar to those we saw in student thinking. While many materials discuss some types of energy production, overpopulation, and some types of food production and food shortages (outside the United States), they do not deal systemically with the links between energy and food production or the links between food production and feeding people. Generally they do not address such connecting variables as nutrition, labor, agricultural technology, and distribution—precisely those variables that can be the points of human intervention. Several "missed opportunities" struck us:

- Few curricula address the recently experienced impact of fuel shortages on food prices. Such a discussion would make concrete the important link between energy and food production. (Odum and Odum's *Energy Basis for Man and Nature* is an exception in this respect.)

- Concerning nutrition, many materials teach students how to plant a seed or a garden. But they do not address whether, or to what extent, people could survive on the produce. Only a few explore the comparative nutritional values of different foods.
- With respect to food production and distribution, the perspectives suggested in Schumaker's *Small Is Beautiful* (on decentralization and intermediate technologies) were not explored in many materials, although these would seem to be provocative for students. ("Baldicer" and "The Science and Mankind" series are rare examples of materials that do address food allocation.)
- Regarding the human element in food production, we found no discussions of the effect of labor strikes, of government policy on a national or international level, of land and other resource ownership patterns. When materials do address ownership in passing, they present partially anachronistic views of small farms owned by Farmer Jones and Farmer Brown. The human contribution in terms of technology is also neglected. Although the "green revolution" may have brought problems as well as benefits, it is surprising that few materials discuss it. It would seem that students should know about the major attempts to solve problems, and their resulting costs and benefits.

In summary, while the major problems of overpopulation and resource-and-energy availability are usually presented, there is little exploration of connections between them that could lead students to:

- a systemic view and understanding of the concept, "you can never do just one thing"
- seeing the potential points for human intervention

Problem Identification and Solving Skills

Problem Identification

Students we interviewed were unclear how to decide whether a reported problem is in fact a problem—other than looking around them or relying on the opinions of others. "Looking around them" means the problem must exist in almost critical proportions for students to recognize it. Student responses indicate uncertainty about what problems exist, and inability to decide what constitutes a problem.

Most of the materials we reviewed do not give students needed help in learning to identify problems. They feature issues that are known problems, and then help students to understand and work with these issues. Students also need:

- to recognize that something is or may become a problem
- to assess the seriousness of a problem

Problem Solving

When students were asked how various problems they cited might be solved, they suggested two methods: laws reinforced by severe punishment, and technology. Clearly they saw solutions in the hands of others, "out there" somewhere.

Although many curricula do address problem solving, opportunities to practice problem solving are generally limited to data gathering. Few curricula give practice in such problem-solving steps as:

- designing alternatives
- considering costs and benefits from several points of view
- choosing among solutions
- advocacy
- making projections

Analytic Skills

Systems analysis skills and other skills involved in analyzing a "problem-in-motion" are tackled by only 4 percent of the curricula. A "problem-in-motion" is one that is changing continually because new circumstances arise both spontaneously and as a result of human response to the problem. Few, if any, of the problems students presently solve in schools are presented as "problems-in-motion." Students need to learn:

- how to analyze such changing problems
- how to step back from a problem and, before seeking a specific answer, decide what a solution would look like—what elements it must contain, and which of these must change for the problem to be solved (in growth problems, for instance, most "solutions" involve energy or resources, distribution, and attitudes)
- how to choose among alternatives when the best data available are ambiguous and provisional
- how to make mid-course corrections—how to get information and adjust solutions without pulling up everything by the roots

Creativity

Problem-solving skills that build creativity are missing from all materials except several of the future studies courses. Students can be taught to use "think-tank" skills such as brainstorming (to enlarge the number of alternative solutions considered), or to use metaphor or analogy to open up existing "gestaldts" to new insights. Such problem-solving skills are needed to develop *new* ways of approaching problems, approaches for which there are not yet any categories.*

Collaborative Skills

Team-building activities are another kind of creativity-building activity missing from most of the materials we sampled—activities such as the "squares game" developed by D. Nylen, H. R. Mitchell, and A. Stout (*Today's Education*, VIII, October 1969) which improve the ability of people to work together and use the resources already existing in the group. The Port Huron, Michigan, and the Dover-Sherborn and Brockton, Massachusetts, programs are among the few that provide opportunities for genuinely collaborative problem study. Collaborative problem-solving skills are important, since effective responses to growth problems clearly require action.

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* For a good and extensive presentation of ways to develop creativity, see *The Practice of Creativity: A Manual for Dynamic Group Problem Solving* by George M. Prince (New York: Macmillan, 1970).

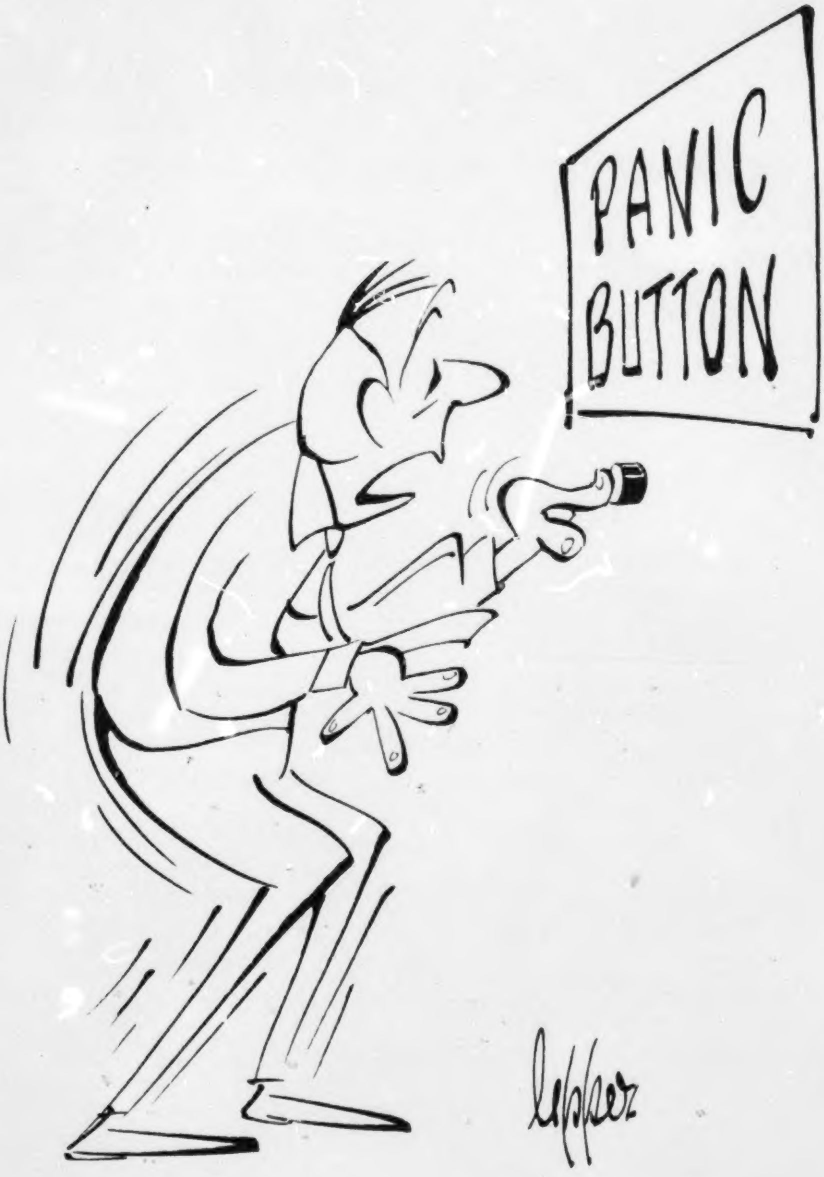
The Role of Human Resourcefulness

During the interviews, students indicated that they do not feel empowered to deal effectively with future problems. They relegate solutions to the scientific community. Except for specific technological advances (and these would have to be made "in time" to have effect), students do not appear to see personal or community resourcefulness as having a potentially positive effect on the problems of the future. A teacher-educator interviewed in Minnesota described it this way:

> Kids—at least in Minnesota—seem to understand ecological concepts pretty well, but have not applied them to thinking about the future. Kids think that the future is beyond their control—they can't impact on any decisions.

The curriculum review shows that materials in the sample do nothing to counter this view. Although students are frequently exhorted to take responsibility for the future, they receive little guidance for doing so. Besides failing to teach creativity skills and collaborative skills (as already mentioned), the materials provide few positive role models: people who, through their personal efforts and resourcefulness, have made significant technical or social changes; people who have shown effective altruism and group concern in creative ways in their daily lives. In stressing the enormity of future problems and the "costs of progress," the positive potential of human creativity has been neglected. Litterers have been personalized, while scientists, engineers, and public servants appear at best as institutions. One-page presentations of scientific "heroes," or brief abstract descriptions of communities that have made some changes are ineffective for engendering identifications, because they do not describe in depth the strengths and limitations of the people involved and their feelings at important points of decision. Fully developed case studies are needed, not one-page biographical highlights.

The most common role possibility presented to youngsters is that of being a careful citizen who doesn't litter and who cuts down on consuming. These are not satisfying goals for teenagers, who are at a point in the life cycle where they need empowering role possibilities as they prepare for adulthood. Students at this age have a great deal of energy and are more interested in developing competence than restraint. Moreover, failure to capture their imagination and energy is a waste of the human resources the nation needs.


PANIC BUTTON

" IT'S STUCK ! "

Pedagogy and Teacher Preparation

Most materials in our sample fail to provide a range of learning modes—materials tend to be limited to readings and discussion exercises. When materials do include films, audio-tapes, or games, they frequently do not provide a context. As one biology teacher described the problem:

> I do object to what I call the "showing movies syndrome."... For one thing, the films we have here are mostly out-of-date. But more importantly, no matter what you do in the class—show a film, do a case study, do an experiment—*you have to have the proper surround.*

Students bring different interests and ways of learning into the classroom. Few curricula provide a range of materials that address the diversity among students, or that allow the individual learner to utilize several ways of perceiving, thinking, feeling, and acting.

In addition to needing a *range* of materials and teaching strategies for students, teachers need some self-preparation for teaching about growth and future issues. Teachers and teacher-educators whom we interviewed addressed a range of problems, but ultimately they focused on teacher education as the key intervention point:

> Teachers extract ideas. You can prepare the best booklet or course in the world and it won't get used unless there is some way for teachers to pick and choose among materials. You've got to reach the teachers first.
>
> I'm very upset by the glib, poorly thought-out materials that are around today. My top priority—outside of better teacher education—would be for *quality control* in the field. There is a "preciousness" about many of the materials that doesn't really involve any kind of real appreciation of the ecosystem as a *live* system. . . . Personally, I feel the need for more effective training methods for teachers—but then that might be my own personal bias. I would put the need for new student materials or workbooks second.

In the classroom, the challenges these curricula present teachers include:

- interdisciplinary content (involving a number of disciplines as well as methods for integrating them)

- emotional impact
- values implications
- provision of "hands-on," community-related activities

Helping students find meaningful intervention points in the larger system that are attuned to their personal concerns and life situation is an essential and difficult task for teachers. Yet more than half of the materials provide no teacher guides. Where teacher guides do exist, they rarely offer help with emotional or value-laden issues or the new skills and content teachers may need to learn.

Teachers and administrators also need preparation for handling implementation issues that arise outside the classroom. Interviewed teachers emphasized the need to consider the multidisciplinary nature of a "growth-and-future" program within a framework of established subject areas:

> Forty percent of the students—they don't go on to college. If you interest and alert kids in high school in good, wholesome, empowering ways so that they're knowledgeable about environmental issues, you'll have them interested and involved for the rest of their lives. To do this, you have to take an interdisciplinary approach—bring in the art teachers, the English teachers—and let people work together.

* * * * *

> You have to introduce something new within the framework of subjects teachers are now teaching or have been asigned to teach. You can't separate a curriculum and say now you're going to spend a year on environmental education. What a strain that places on teachers. You've got to be realistic. When you're hired, the school charges teachers with teaching a certain subject—biology, social studies, etc. And if anything, schools today seem to be going backward in this regard; they used to be more flexible. And then the kids are going to be taking the AP [Advanced Placement] test in biology. And they're not going to have 300 questions on environmental education or food or energy. That just doesn't happen. So I have a responsibility to the community, to the school, and to the kids. I know publishers have changed but they have to realize that we can't take a whole course on "the environment," "growth and survival," etc.

None of the materials we reviewed addressed a range of implementation issues.

Some Thoughts about an Adequate Curriculum

Our conclusions result in a long, sobering list of perspectives, skills, content, and teacher support—elements that are lacking from most of the materials reviewed. Many curricula have valuable elements—some more than others—but none has the overall framework and perspective we consider important for a program on growth and the earth's future. The real task, after all, is an enormous one—it involves changing the way students think, from a linear exploration of single factors to a systemic exploration of a web of factors and the way the factors interrelate.

The list of missing elements forces the question, "How can one curriculum do everything?" We do not feel that one year-long curriculum can cover every relevant topic; if it attempted to do this, it would become a superficial survey. A single curriculum can go a long way, however, in the study of any topic.

In our view, the elements of an adequate curriculum would be shaped in the following ways.

Questions

The kinds of questions the curriculum asks will support a systemic approach, generating answers that often begin with "It depends on. . ."

Concepts

An adequate curriculum will deal with any one issue by using not only concepts from all relevant social and physical sciences, but also concepts *about* systems, *about* change—about human and environmental responses to growth, and about the ways problems are solved.

Disciplines and Sources of Expertise

On any one issue, sources will be both theoretical and practical. The curriculum will draw on concepts from social and natural sciences; systems theory; synectics; and case study material from such people as engineers, ecologists, and pyschologists, as well as from lay people who have dealt with growth changes in their communities.

Learning Modes and Strategies

A range of media and teaching strategies will be used in presenting any one issue: film, audio-tape, print, discussion, lecture, brainstorming, case study analysis, small-group work, past and present life experience. Students will engage in concept learning, problem solving, discussion of feelings and attitudes, artistic modes of expression. Metaphor and analogy will be particularly important teaching tools in this effort to create new ways of perceiving and solving problems. Collaboration will be stressed.

Relevant Perspectives

For any one issue, an adequate curriculum will consider as relevant the history or future of a current situation; the immediate and long-term effect of a situation on local, regional, and global levels; feelings a situation evokes; ways a situation could be changed or accepted.

Skills

The study of any topic will become an opportunity to build skills in problem identification, creative problem solving, problem analysis, and teamwork. It will encourage students to think about a multiplicity of situations and options. It will provide exercises to extend any individual's list of alternatives beyond those already perceived: for example, ways to heat or cool a home; edible foods/possible diets; ways to dig a hole, pump water; ways to divide people into teams or organize a group of individuals into a unit; how to allocate a set of goods or combine a set of production factors; how to arrive at a decision; how to generate analogies of how things grow, change, improve. It will provide basic conceptual tools and indicators that learners can use over time to think about whether conditions are imporving or worsening (in their own terms, and in the perspectives of others).

Learning Experiences

Students will work with real and hypothetical problems, interact with their community, become aware of their own reactions.

Student Role

Students will be active learners engaged in solving problems, acquiring information, asking questions, helping to plan and evaluate their own learning. Exercises will demonstrate that many small solutions can interact to solve a big problem (just as many small problems can interact to cause a big problem).

Teacher Support

Teachers will be helped, through training and/or materials, to deal with the following issues as they relate concretely to each topic:

—helping students decide in the face of conflicting claims whether in fact there is a problem; finding ways to analyze and act on a "problem-in-motion"; and deciding what action to take when the answer is ambiguous

—building creativity

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—developing collaborative skills

—helping students find meaningful intervention points in the larger system

—localizing activities for students and finding ways to cope with community reactions to teaching about growth implications or studying community issues

—acknowledging and dealing with feelings engendered by "growth implications" and future studies

—acknowledging and respecting religious and ethical perspectives

—understanding the network of related topics

—developing a background in particular subject matter disciplines

Evaluation

Methods for evaluating student learning will be provided that use the learning modes of the program. These include problem analysis, problem solving, teamwork, artistic expression.

Community Role

Community members and institutions will have opportunities to take part in the examination of pertinent topics.

Tone

An adequate curriculum must convey a "positive view of the potential of human resourcefulness." Students are already convinced of our sins of the past. They need to know the strengths in our heritage that we can depend on and build upon. While not denying human greed, we need to help students identify the conditions that bring out the best in people. The tone we view as a positive one can best be described in terms of three components: Why we got where we are now, How we will get someplace better, and Where we are going.

1. "Why We Got Where We Are Now"

We believe that most people take short-sighted views not because of stupidity, greed, or lack of ecological education, but because we swim in a social context that evolved over periods when the problems were different.

We live in a social structure that has been dedicated to providing the necessities, to ensuring the common defense, and to keeping people from doing each other harm in the streets. That much, however imperfect, took the better part of 10,000 years. The social structure will not readjust its goals easily, any more than a duck will quickly adjust to detergent-polluted waters. If we sink too, it will be because good solutions to old problems come up against, and create, new problems.

We believe that students will understand this part of the "ethosphere" better if they understand why it evolved, and that its present shortcomings represent a kind of success as well as a kind of failure.

2. "How We Will Get Someplace Better"

A paper by Elizabeth and David Dodson Gray, written in January 1975, conveys a sense of "how" in a way we have seen in no curriculum material. Because the paper represents an important starting point, sections of it are presented below.

The Journey

The Journey as an Ongoing Metaphor

We suggest that in our thinking about how we search for an environmental ethic that the image or mental model of "The Journey" is helpful and suggestive.

A journey suggests a process, a movement, exploring the future as new terrain. When the journey is into the future and its scope includes the whole human and natural world, then there really can be no "experts" —if by expert we mean someone who has "mastered" the subject. On this journey we are instead fellow journeyers, "colleagues," with various strengths and weaknesses, each of whom has something valuable to contribute.

Using the Past That Is in Us on the Journey

Our journey toward the future is a journey to which we bring our past, our history. This is true of us individually. We bring our own human histories; our regional, national, and socio-economic backgrounds; our family and sexual status, our religious backgrounds; our value preferences; and each person's wide range of personal experience.

We also journey with our past in the larger cultural sense, because we bring our cultural past with us, our "attic" of shared history, heroes, symbols, images, traditions, institutions, know-how, and all the rest that comprise our cultural heritage.

These pasts are valuable, for they are our "social capital" out of which we create the images and symbols and ethos of a future "sense of life." This sense of life never emerges out of a vacuum but always grows out of what has been—out of the past that is in us as we journey.

The Emergence of a New Environmental Ethic

> The metaphor of the Journey allows the future its character of being open-ended. Our individual and collective past is the rich soil out of which the future grows, but that past is never simply recapitulated.
>
> When the journeying itself reawakens our sense of interdependence upon one another and upon our natural environment, then we will all grow and change. We will have learned from one another's insights, perspectives, and "windows upon reality." We will fashion together new symbols and new images to go with the old, and we will be building a new sense of all that sustains us in life.
>
> Out of this new "sense of life" the new environmental ethic will arise, born of our efforts, our pasts, our diversity, our interactions, and our interdependence upon one another and upon our natural world.

3. "Where We Are Going"

We do not believe that marching to doomsday and slowing down the trip is a goal likely to motivate students. An adequate curriculum will reinforce confidence that the future is manipulable, that there are choices to be made, that the "limits" are essentially parameters describing our current understandings and perceptions and desires and know-how rather than immutable laws and predestinations. It will pay less attention to "our chances of survival in 2000" than to "what needs to be done to help bring about a world in which we will want to live in 2000," less attention to "how soon the oil will run out" than to "how we can best use oil supplies and what alternative oil utilization policies are possible," less attention to "can the world feed itself" than to "how can the world best feed itself," less attention to the "population explosion" than to "how attitudes toward childbearing may be expected to change and what that will mean for other aspects of society."

Jerry Glenn, one of the founders of the Minnesota Science Museum, believes that we have already begun to witness positive change. After reviewing the first draft of this paper, he commented in part:

> The Lily pond example will be increasingly misleading as we move into the future. The geometric growth rates in population and industrialization are just beginning to turn over. The air and water of the U.S. on the average are cleaner than last year. The U.N. said several years ago that world population would be 10 billion by 2000, then said 8, then 7, and now 5 to 6 billion. Most of the assumptions in your paper were popular three years ago and are now in a process of change. . . . You might get into some of the areas where we're winning. For instance, Pittsburgh is cleaner by far than it was just ten years ago. Also, [you might examine] how to win—what caused the success in Pittsburgh?

Appendix

Student Interview Questions

Reminders: Ask students where they learned any specific information that they provide.

As general probes, each time they mention (within reason, of course) a particular problem such as overpopulation or pollution, ask, "How do you think the problem occurred? Where did you get your information? What could be done to solve the problem? If that didn't work, what else might be done?"

1. If we were to send a group of people to start a permanent colony with their own spaceship in space, and there was no possibility of their returning to earth or landing on another planet, what would that colony need in order to survive?

(How would they get their food?)
(How would you make sure they wouldn't run out of food, etc.?)
(How would they get their power?)
(What other problems would have to be overcome in setting up this colony?)

If you could choose people for this colony, what character traits would you look for? Would they be the same as those that are important in our world today? (If not, how would they be different?)

2. What do you think of the earth as a place to live?

What predictions would you make for it 100 years from now?

If they name only good (bad) things, ask, "Are there any bad (good) things you might expect the future to bring?"

If many kinds of problems are given, ask students which one they consider the most serious.

3. What is rain? (What happens to rainwater after it falls on the ground?)

4. Where is food produced? Do all countries produce food? Could most countries be self-sufficient?

(What would be necessary for a country to be self-sufficient? Is that always possible?)

5. What effect do you think modern technology has had on the earth and its people?

(What do you think have been some of the things scientists have done that affect people today?)

6. The purpose of a thermostat is to keep a room at a particular temperature. It turns the heat on when the room temperature goes down, and turns it off when the room temperature returns to the desired level. Can you think of anything else that works this way to keep something the same?

7. What possessions do you think you will want to have when you are older and are on your own (have a job that pays well)?

If your parents had been asked the same question when they were your age, would they have listed the same kind of things? (How would their list have been different?)

Do you think it will be possible for you to have everything you want? (If so, what might possibly prevent you from having what you want? If not, what would stand in your way?)

8. Why do prices keep rising? (Probe until they can no longer think of reasons. Ask, for example, "What makes the farmers' costs higher?")

9. Is anything on our earth limited? If so, what? What is it limited by? What does that limit in turn?

What will happen when limited things are gone? Will this have any effect on people?

10. About 15 families in a town decided that they would be able to make a lot of extra money in their spare time by raising goats and selling the milk and cheese. They did not have land of their own, but the town itself did own land suitable for grazing in the area. They proposed to the Town Manager that each family be allowed to bring two goats to the area to graze. Permission was granted and in the first year everyone made a profit. The people then talked about buying more goats the second year, because the demand for cheese and milk was still greater than the supply. They anticipated an even more prosperous second year.

What do you think would happen over time if the demand for milk and cheese continued to remain higher than the supply?

(Do you think they would encounter problems? What? If so, how might they be solved? What would happen to the land?)

Can you think of anything similar that has happened?

11. What do you think are the worst problems facing our world today? How do you think each of these problems occurred?

Which problems do you think can be dealt with? What can be done about them? (How might they be solved?)

If that didn't work, then what?

12. How would you go about deciding whether or not a particular problem such as ____________________ (name something the student has cited) is in fact a problem?

13. Do you think that scientists and engineers will be able to solve the problems we're having with the earth's energy and resources? (Can you give any examples that lead you to believe that?)

14. When scientists try to solve some of the problems with the earth's energy and resources, do you think that they make matters better or worse? (Can you give examples?)

15. Who controls actions such as damming a river that runs through several countries? (Who should control them?)

16. What kinds of things do we have control over (technological, social, personal)?

17. When people tell you about problems we might have in the future, how do you sort out their opinions for yourself?

18. Have you ever used a computer?

What is your understanding of how computers work?

19. Have you ever studied any of the topics we have discussed today? Which ones? When? What do you especially remember?

20. Would you be interested in learning more about these topics? What would you be most interested in knowing more about?

Publishers Surveyed

Addison Wesley
Reading, Mass. 01867

Allyn and Bacon, Inc.
470 Atlantic Avenue
Boston, Mass. 02210

Atheneum Publishers
122 East 42nd Street
New York, N.Y. 10017

Basic Books, Inc.
10 East 53rd Street
New York, N.Y. 10022

Beacon Press
25 Beacon Street
Boston, Mass. 02108

Behavioral Publications, Inc.
72 Fifth Avenue
New York, N.Y. 10011

Bobbs-Merrill Co.
4300 East 62nd Street
Indianapolis, Ind. 46206

Thomas Y. Crowell Company
666 Fifth Avenue
New York, N.Y. 10019

Dell Publishing Co.
One Dag Hammarskjold Plaza
New York, N.Y. 10017

Denoyer Geppert Company
5325 Ravenswood Avenue
Chicago, Ill. 60640

Doubleday and Company
245 Park Avenue
New York, N.Y. 10017

Geological Society of America
3300 Penrose Place
Boulder, Colo. 80301

Ginn and Company
191 Spring Street
Lexington, Mass. 02173

Grosset and Dunlap
51 Madison Avenue
New York, N.Y. 10010

Harcourt Brace Jovanovich, Inc.
757 Third Avenue
New York, N.Y. 10017

Harper and Row
10 East 53rd Street
New York, N.Y. 10022

D.C. Heath
125 Spring Street
Lexington, Mass. 02173

Holt, Rinehart and Winston
383 Madison Avenue
New York, N.Y. 10017

Houghton Mifflin Company
1 Beacon Street
Boston, Mass. 02107

J.B. Lippincott
East Washington Square
Philadelphia, Pa. 19015

Little, Brown and Co.
34 Beacon Street
Boston, Mass. 02106

McGraw-Hill
1221 Avenue of the Americas
New York, N.Y. 10020

The Macmillan Company
866 Third Avenue
New York, N.Y. 10022

National Geographic Society
17th and M Streets, N.W.
Washington, D.C. 20036

Prentice-Hall, Inc.
Englewood Cliffs, N.J. 07632

Random House
201 East 50th Street
New York, N.Y. 10022

Scott, Foresman and Company
1900 East Lake Avenue
Glenview, Ill. 60025

Silver Burdett Company
250 James Street
Morristown, N.J. 07906

Simon and Schuster
630 Fifth Avenue
New York, N.Y. 10020

The Viking Press, Inc.
625 Madison Avenue
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John Wiley and Sons
605 Third Avenue
New York, N.Y. 10016

Educators and Practitioners Interviewed

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Jeannette Atkinson
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Science Museum of Minnesota
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Project Quest
Brockton High School
Brockton, Mass.

Kenneth Britting
Sloan School, MIT
Cambridge, Mass.

Robert Cahn
Conservation Foundation
Washington, D.C.

Don Conway
American Institute of Architects
Washington, D.C.

Ralph Cortight
Staff Liaison
National Education Association
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Conyers, Ga.

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Newton North High School
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Reviewer ____________

CURRICULUM REVIEW FORM

Title: ____________

Developer/Author: ____________

Publisher: ____________

Cost: ____________ Copyright date: ____________

Grade level

- ____ 1-3 (primary)
- ____ 4-6 (elementary)
- ____ 6-8 (middle/jr. high)
- ____ 9-12 (high school)
- ____ Other (specify) ____________

Reading level

- ____ Easy
- ____ Average
- ____ Hard

Classroom setting (if specified)

- ____ Biology
- ____ Current problems, civics, etc.
- ____ General science
- ____ History
- ____ Social studies
- ____ Other (specify) ____________

Scope (check any that apply)

- ____ Interdisciplinary
- ____ Single-problem focus
- ____ Multifaceted, interrelated conditions

Teaching time

- ____ One week
- ____ One month
- ____ 2-3 months
- ____ Semester
- ____ Year
- ____ Other (specify) ____________
- ____ Unclear

Comments ____________

____

____

Materials (include all media)

____

____

____

____

____

____

____

____

____

____

____________ reference

Reviewer ____________

1. Goals/Learning Objectives ___ Stated ___ Inferred

____

____

____

____

2. Concepts

What emphasis is given to each of the following concepts? (Has the concept been dealt with to the degree and in the manner we want?)

	Stressed/Integral	Touched on
Adjustment mechanisms:		
market	____	____
technological	____	____
political	____	____
social	____	____
biological	____	____
Biosphere systems (life-support systems in nature)	____	____
Commons behavior ("tragedy of the commons")	____	____
Delayed effect (in time)	____	____
Delayed effect (in space)	____	____
Disaggregation and provisional boundaries	____	____
Dynamic behavior of systems	____	____
Entropy	____	____
Ethosphere systems (societal life-support systems	____	____
Exponential growth	____	____
Intervention points	____	____
Limits (constraints to growth)	____	____
Moving (dynamic) equilibrium	____	____
Paradigms	____	____
Sources and sinks	____	____
The 200-year present	____	____
Trade-offs	____	____

________________ reference

Reviewer ________________

3. Subject Matter

What subject(s) does the course use to teach its concepts (e.g., coral reefs, automobiles, life of the forest, cross-cultural life styles)?

____

____

____

____

4. Skills

What emphasis is given to development of each of the following skills? (Has the skill been dealt with to the degree and in the manner we want?)

	Stressed/Integral	Touched on
Assessing existence of problems	___	___
Problem solving:		
problem identification	___	___
data gathering	___	___
creation, use of hypotheses	___	___
analysis	___	___
design of alternative solutions	___	___
consideration of costs and benefits from several points of view	___	___
choice of solutions	___	___
Systems analysis:		
creation, use of conceptual models of systems	___	___
creation, use of cause and effect loops	___	___
disaggregation	___	___
Making and evaluating projections	___	___
Advocacy	___	___
Identification of own role in cause and solution of problems	___	___

________________ reference
Reviewer ________________

5. Affective Domain

a. What value orientation seems most predominant in this course?

____
____
____
____

b. Which of the following values and attitudes does the course appear to foster?

	Stressed/Integral	Touched on
Acceptance of limits	____	____
Growth as necessary and good	____	____
Responsibility for the future	____	____
Sense of identity with (place in) the ethosphere and biosphere	____	____
Sense of involvement in:		
community	____	____
nation	____	____
world	____	____
Sense of empowerment	____	____
Pleasures of pruning down ("I can be happy with less.")	____	____
Sense of "enoughness" ("I don't need/want more.")	____	____
Technology will save us ("Increased technology is the answer.")	____	____
Sense of hopelessness	____	____
Other ________________	____	____

c. Effect on morale: What provisions are made for helping students cope with difficult emotions aroused by the course?

____
____

____ Ways to do something on one's own to improve environmental conditions are suggested.
____ The problem is dealt with directly in student materials.
____ Instructions/cautions/suggestions appear in teacher materials.
____ Effect on morale is not likely to be a problem in this course.

____ reference
Reviewer ____

6. Pedagogy/Learning Strategies

a. Which of these methods does the course use extensively?

____ Reading
____ Small-group discussion
____ Class discussion
____ Structured questions and answers
____ Games
____ Role play
____ Debate

____ Research
____ Classroom experiment and hands-on ecology
____ Community action
____ Lecture
____ Guest speaker
____ Apprenticeship
____ In-depth case study

____ Other ____

b. What approaches are used to arouse eco-consciousness?

____ Threat/fear
____ Fable/imagery
____ Fantasy
____ Student projects in the field

____ Models of positive approaches others have taken
____ Data about the future
____ Field trip

____ Other ____

c. Is the course geared to local adaptability? ____

____ Via subject matter (in student or teacher materials)
____ Via community involvement/action
____ Other ____

7. Teacher Support

a. Teacher's guide(s)

Notable strength? ____

Notable weakness? ____

b. What teacher training/staff development elements are included? (e.g., workshops, tapes)

____

What evaluation materials/instruments are supplied with the course?

____ Interview forms
____ Questionnaires
____ Observation forms/guides
____ Sample tests
____ Other ____

Are the materials:
____ teacher focused?
____ student focused?

____________ reference

Reviewer ____________

8. Overall Assessment

a. How *comprehensive* is the curriculum . . .

	Very	Some-what	Not at all
in supplying both teachers and students with a variety of means for meeting its goals?	____	____	____
in dealing with the concepts and concerns identified by this project?	____	____	____

b. How much does it address the *future?*

- ____ Very much
- ____ Slightly
- ____ Not at all

c. To whom does it seem *addressed?*

____ Urban ____ Suburban
____ Rural ____ Mixed

d. Does it have a specific *regional geographical focus?* ____________

If yes, specify ____

____

e. Could it be translated/adapted easily for *international use?* ____

(Would its perspective and scope make it amenable to this?)

Comments ____

____

f. What major strengths or weaknesses did you find in the curriculum?

(Circle applicable term and describe.)

____

____

g. Was this curriculum notably similar to others? How?

____

____

h. Was it notably different or distinctive? How?

____

____

i. Do the materials raise any new problems that we should be aware of when we design a growth and survival curriculum?

____

____

____________ reference

Reviewer ____________

9. Useables/Adaptables

Please list any materials, parts, or aspects of the course that you feel we should review later for possible use in an EDC curriculum.

10. Comments/Reactions/Evaluations

From teachers and students who have used these materials:

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